Try It
YOURSELF

A BOOK OF SCIENCE PROJECTS AND EXPERIMENTS

ARORA'S

Try It Yourself packed with practical experiments and fun projects and introduction to the world of science for the entire family.

This superb book contains 150 questions and their answers on **air--chemistry--light--magnetism--electricity** and **water** such as : What is in the air? Does heat change a substance? How is electric current generated? How does light spread? Can magnets attract anything? Why does it make water move about? Besides this book contains a safe and easy way to learn about the fascinating **world of science**. You can try these experiments yourself or with a group of friends, teachers or parents. Materials required are easily available at home, laboratory or market. First, you complete an experiment then you go through the conclusions given in the book. Did you come up with the few answers? You may come up with a few conclusions of your own.

Full-colour illustrations and photographs and step-by-step instructions show exactly how to carry out each experiment, and a lively text explains even the most complex principles simply and clearly. Throughout the book, there are fascinating features on many aspects of science. Information boxes put the spotlight on famous scientists and critical movements in the history of scientific discovery. This book is ideal for use at home and school.

Try It Yourself

A Book of Science Projects and Experiments

Compiled by a team of
Science Writers and Specialists

This book belongs to :

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ARORA'S

Rs. 150/-

Try It Yourself

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WARNING

This encyclopedia contains many illustrations and photographs of experiments and demonstrations that show science in action. These were carried out under carefully controlled conditions in a laboratory. It is dangerous for readers to perform these experiments and demonstrations themselves.

Publisher will be not responsible for any type of accident or mishap.

PREFACE

Experiments are the key to the success of science. By trying out what happens when they slightly alter the natural world, scientists can collect information that gives them ideas about how the world works. They can test and compare different theories to see which one is the most useful for describing the world's behaviour, and can develop effective new equipments, chemicals, and techniques.

Experiments can be useful for convincing the people about a scientific theory. In a dangerous and dramatic experiment designed to demonstrate that lightning discharges are a form of electricity, in 1752, Benjamin Franklin flew a kite in a thunderstorm. Electricity passed down the damp string to a key at the other end. When he put a finger near the key, a spark bumped between them. Franklin concluded that electricity in clouds caused the spark and that lightning is a kind of spark too.

Modern scientific experiments are so complex that people often work in teams. Each team member contributes his or her own particular knowledge and skills. Some scientists organize the team and their apparatus.

This superb book contains over 150 questions and answers like these : Where can we find air? What is lighting? How does water move? Discover the answers to these and other charming questions of science with approx. 150 skilful experiments! You will find information boxes, which highlight particular aspects of a main entry. The best way to find out is through observation and experimentation. First you must have a question : then you think of a way to find the answer. Each of the experiments that follow start with a question. Read the activity thoroughly & completely before you begin, and be sure you have all the materials at hand. Sometimes finding an answer will move you to more questions. If so, go ahead and design your own experiments and keep a notebook to record your results. Have fun! next page will show how to use this book..

— PUBLISHER

ABOUT THIS BOOK

Running head reminds you which chapter you are in and to help you find place in the topic.

AIR AND COMBUSTION

WHAT IS IN THE AIR?

Question

Air is a mixture of gases: Of these, oxygen and nitrogen have the largest share.

Answer

TRY IT YOURSELF

Try it yourself shows you how to do simple experiments and make things. They will help you understand the subject you are looking up.

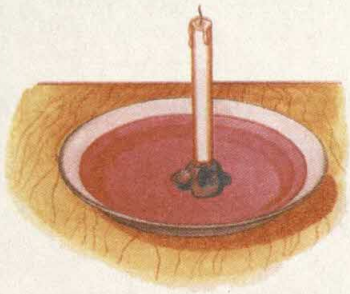
Things you will need

- ★ A soup plate
- ★ A candle
- ★ A clear glass jar
- ★ Water
- ★ Ink
- ★ A match
- ★ Modelling clay

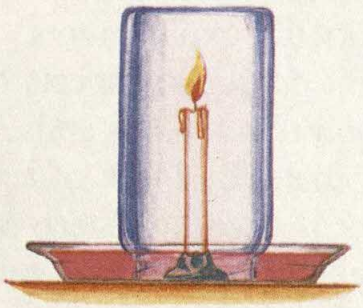
Directions

Step-by-step instructions show you how to do the experiments.

1. Fix the candle in the plate with a little modelling clay.



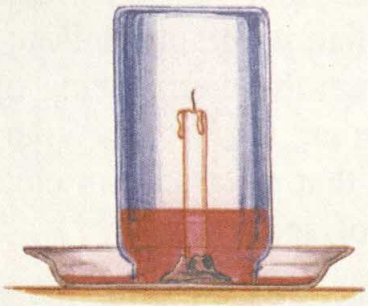
2. Pour a little water into the plate. Add a few drops of ink so that the water is easier to see.



3. Ask an adult to light the candle. Then cover it with the glass jar.

Result

After a few moments, the flame goes out and the water from the plate rises up into the jar, taking up about a fifth of the space.



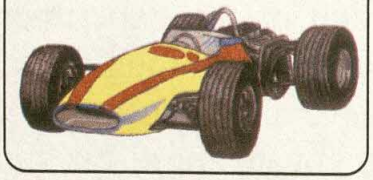
Reason

Because the candle, as it burns, uses up one part of air, called oxygen. The water, pushed up by the pressure of the air outside, enters into the jar, taking up the space left by the oxygen. But it cannot fill the jar completely because the rest of the air, which is mostly nitrogen, still takes up space inside.

AIR AND ENERGY

Like other cars, this racing car gets its energy from petrol burning in its engine. Burning fuel provides most of the energy we use for heating and powering machines. This process uses oxygen, which comes from the air around us.

Special information box.



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Safety and Warning Symbols

We all come across dangerous and poisonous substances in our everyday lives, but they are not always apparent. To help us identify them, safety codes, a combination of pictures and words are used as warning symbols. It is essential for your health and safety that you follow these.

Safety Sense

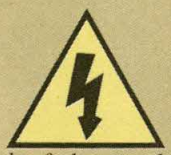
Here are a few simple rules you should always follow in your laboratory :-

1. **Always** follow all the steps in each experiment carefully.
2. **Take care** especially when handling hot or heavy objects, glass, scissors, matches, candles and batteries.
3. **Do not** smell things, put them in your ears or mouth, or close to your eyes unless the book tells you to do so.
4. **Do not** play with electric switches, plugs, power points and electrical machines.
5. **Make sure** you clean up after each experiment.

Safety Signs

1. Safety signs may be fixed to doors, cupboards, or other areas of a laboratory to warn of a nearby hazard or a hazardous substance. Each symbol is enclosed in a triangle and has yellow background examples include.

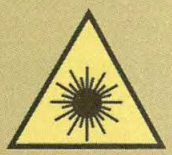
Danger



Risk of electric shock (dangerous voltage)

Radiation risk

Flammable liquid



Laser radiation

2. Hazardous equipment and containers of hazardous materials may also carry warning symbols. Each symbol is enclosed within a square.

Wear protective clothes

Wear glasses

Wear gloves

Wear welding mask

Wear ear protectors

Wear boots

First aid

Harmful chemicals

Highly flammable

Dangerous chemicals

Oxidizing

Poisonous substances

Other Safety Symbols

Eye protection must be worn

No smoking

AIR

Air is all around us..... It surrounds the Earth in a layer called the atmosphere. All living things must have air in order to live. Air is colourless and has no smell. Yet it is really a mixture of a number of different gases. We can feel air when the wind blows, and we know air has weight. Air carries sounds.....without it we would not be able to hear, because sounds cannot travel in a VACUUM.

The chief gas in air is nitrogen, which makes up nearby four fifths of the air. About one fifth of the air is made up of OXYGEN. Air holds some water in very fine particles called vapour. We find the degree of HUMIDITY in the air by measuring the amount of vapour.

Air expands when it is heated and when it expands it becomes lighter. This is why warm air rises.

The air that surrounds the earth gets thinner the higher you go. All high flying aircraft have to keep the air in their cabins at ground level pressure so that passengers can breathe normally. In the same way, mountaineers carry their own air supply because the air at the top of high mountains is too thin for normal breathing.

You will find the answers about *"air pressure, hot air and cold air, air is everywhere, air and combustion, flight and sounds and many other questions"* by doing the experiments in the following pages.

AIR IS EVERYWHERE

WHERE CAN WE FIND AIR ?

Air is all around. It occupies every free space, however small.

TRY IT YOURSELF

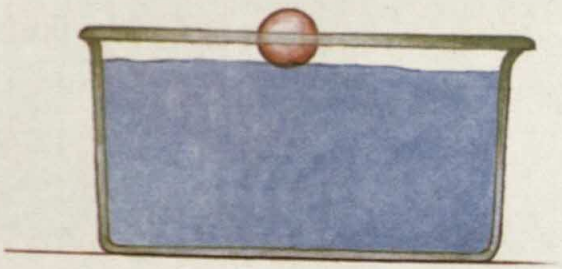
Things you will need

* A Glass jar
* Ping-pong ball
* Piece of kitchen paper
* Transparent bowl or basin containing water

Directions

1. Place the paper in the bottom of the jar so that it cannot move about.

2. Place the ping-pong ball on the surface of the water in the bowl.



3. Turn the jar upside down over the ping-pong ball. Press down with the jar until it touches the bottom of the bowl.

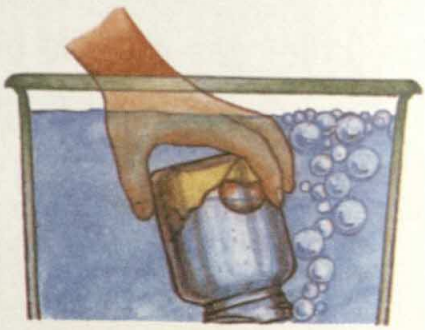
Result

The water does not get into the jar and the ping-pong ball is resting on the bottom of the bowl, almost dry.

Reason

Because, the air in the jar stops the water from getting in and making the paper wet. Lift the jar straight up out of the water and you will see that the paper is barely wet, almost as if the jar has just been drained!

4. Immerse the jar once again.



5. When it touches the bottom, tilt it a little.

Result

Bubbles of air escape from the jar. These rise to the surface and burst. Water gets into the jar, the ball rises higher inside and the paper gets wet.

Reason

Because, the air inside the jar finds a way of escape and rises upwards. Now the water takes up the space which has been left by the air.

AIR IS EVERYWHERE

DOES AIR HAVE WEIGHT ?

Even something which may seem as light as air has weight.

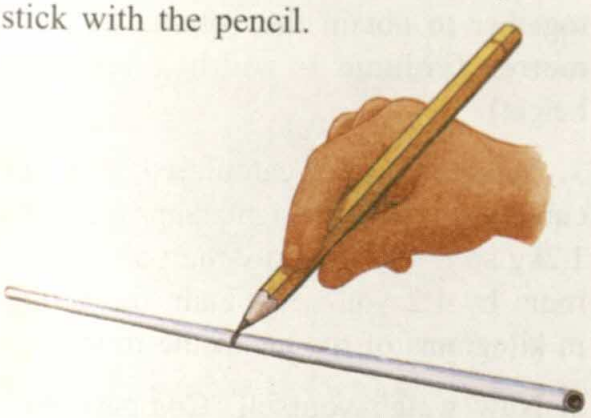
TRY IT YOURSELF

Things you will need

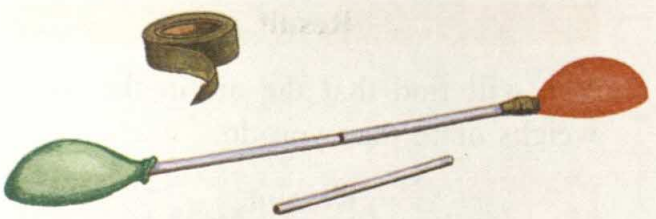
- ★ Two plastic sticks, one 15cm and one 30cm
- ★ Balloons of equal size, each slightly inflated
- ★ Two cans of drink
- ★ Sticky tape
- ★ Pencil

Directions

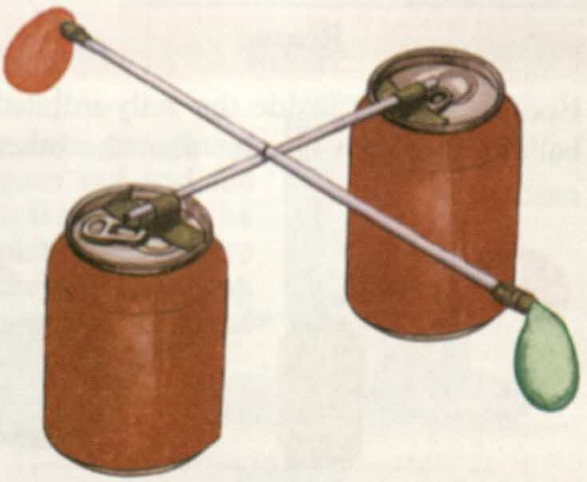
1. Mark the centre of the 30cm plastic stick with the pencil.



2. Fix one balloon at each end of the stick with the sticky tape.



3. Tape either end of the 15cm plastic stick to a can. Place the centre mark of the 30cm stick on top.



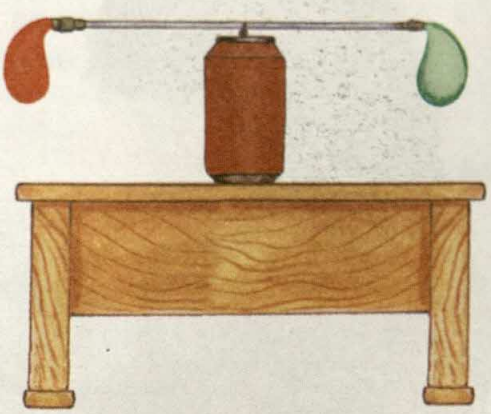
Result

The stick with the two balloons stays horizontal.

Reason

Because the balloons are of equal weight.

4. Remove one balloon and inflate it fully. Reattach it to the 30cm plastic stick, making sure that this is balanced the same as before.

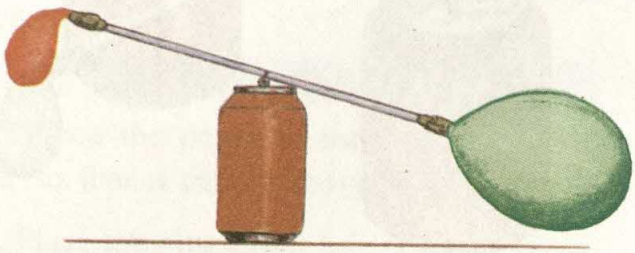


Result

The fully-inflated balloon weights down the long plastic stick at one end.

Reason

Because the air inside the fully-inflated balloon makes it heavier than the other one.



DRINKING WITH A STRAW

When you drink through a straw, the weight of the air helps you. The air above the drink pushes on the surface of the liquid. As you suck, it forces the liquid up through the straw to your mouth.

How to calculate air weight in a room?

TRY IT YOURSELF

Things you will need

- ★ A metre rule
- ★ Pen and Paper
- ★ Bathroom scales

Directions

1. Take the measurement of a room in metres. (This is best done from one corner to another.) Measure the width and the length of the floor and the height of one wall.

2. Multiply the three measurements together to obtain the volume in cubic metres (volume = width x length x height).

3. Scientists have calculated that one cubic metre of air weights approximately 1.2kg so if you multiply the volume of a room by 1.2 you will obtain the weight in kilograms of the air in the room.

4. Now weigh yourself. Compare your own weight with that of the air in the room. Which is the most ?

Result

You will find that the air in the room weighs more than you do.

Reason

Because the air in a medium-size room is equal to that of an adult person (about 70kg.).

AIR AND COMBUSTION

WHAT IS IN THE AIR?

Air is a mixture of gases: of these, oxygen and nitrogen have the largest share.

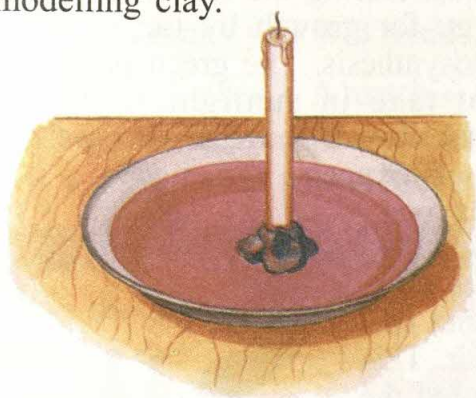
TRY IT YOURSELF

Things you will need

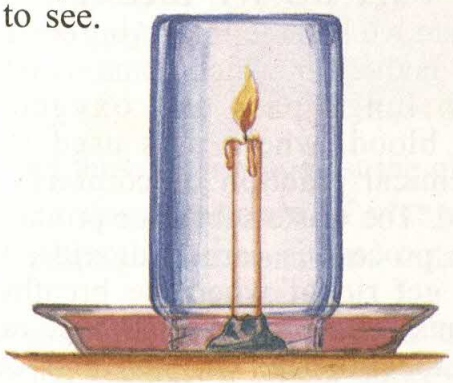
- A soup plate
- A candle
- A clear glass jar
- Water
- Ink
- A match
- Modelling clay

Directions

1. Fix the candle in the plate with a little modelling clay.



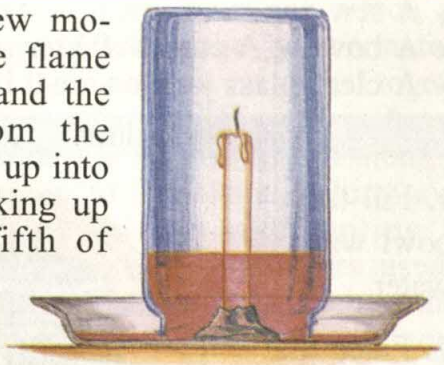
2. Pour a little water into the plate. Add a few drops of ink so that the water is easier to see.



3. Ask an adult to light the candle. Then cover it with the glass jar.

Result

After a few moments, the flame goes out and the water from the plate rises up into the jar, taking up about a fifth of the space.



Reason

Because the candle, as it burns, uses up one part of air, called oxygen. The water, pushed up by the pressure of the air outside, enters into the jar, taking up the space left by the oxygen. But it cannot fill the jar completely because the rest of the air, which is mostly nitrogen, still takes up space inside.

AIR AND ENERGY

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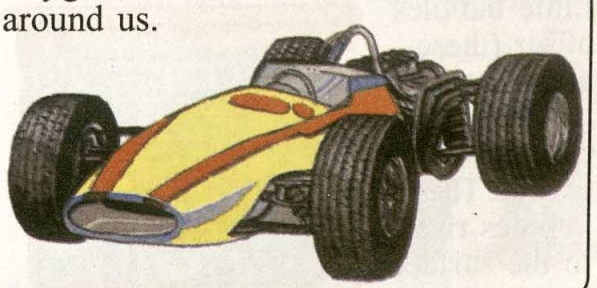


AIR AND COMBUSTION

HOW IS OXYGEN AND CARBON DIOXIDE MADE ?

Oxygen is produced by plants. Carbon dioxide is mostly breathed out by humans and animals.

TRY IT YOURSELF

Things you will need

- ★ A few sprigs of a water plant
- ★ A bowl ★ A card ★ Water
- ★ A clear glass jar or vase

Directions

1. Fill the bowl with water.

2. Place the sprigs in the jar then fill this with water.

3. Cover the mouth of the jar with a card. Keeping your hand on the card, carefully turn the jar upside down, and lower gently into the bowl.

4. Place the bowl in sunlight. Remove the card carefully.

Result

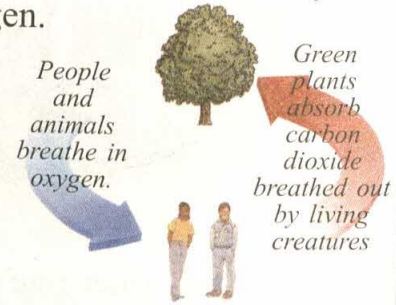
Little bubbles of air (these are full of oxygen) collect on the leaves. The bubbles rise to the surface.

Reason

Because the leaves of the water plant, just like plants on the ground, release oxygen in the presence of sunlight. Oxygen is invisible, but we can see the leaves releasing it under water.

OXYGEN CYCLE

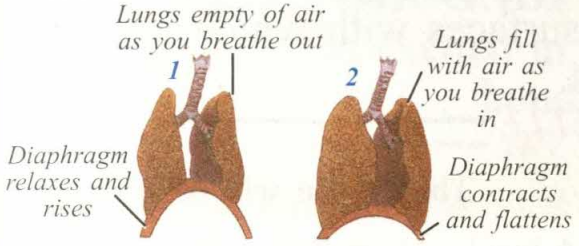
Breathing air or burning fuel removes oxygen from the atmosphere and gives off carbon dioxide. Plants do the reverse. During the day, they produce energy for growth by the process of photosynthesis. The green parts of the plant take in sunlight, water, and carbon dioxide to make new cells, and give off oxygen. So oxygen continually passes into and out of the air. This is called the oxygen cycle.



WHY DO WE BREATHE ?

When we breathe in, we introduce into our bodies air which contains oxygen. Our lungs pass the oxygen into the blood, where it is used for the chemical reaction of combustion of food. The waste substance produced by this process is carbon dioxide, which we get rid of when we breathe out. Plants then use carbon dioxide in their photosynthesis. Oxygen and carbon dioxide continue to be breathed in and out for as long as we live.

BREATHING



1. ***Breathing out*** *(carbon dioxide) When you breathe out, the diaphragm and chest muscles relax. The lungs are spongy and elastic, so they spring back to their smaller size after they have been stretched. This blows air (carbon dioxide) back out of the lungs.*

2. ***Breathing in*** *(oxygen) When you breathe in, the diaphragm contracts (becomes flatter) and pulls down the base of the lungs. Muscles between the ribs contract to swing the ribs up and out. These actions stretch and enlarge the lungs, so that air (oxygen) is sucked in.*

Things you will need

★ A plate ★ A glass ★ A match ★ A candle ★ A teaspoon ★ Vinegar ★ Bicarbonate of soda ★ A cardboard tube ★ Modelling clay

Directions

1. Fix the candle on to the plate with a piece of clay. Ask an adult to light the candle.

2. Hold three fingers against the glass and pour in this a measure of vinegar. Add one teaspoon bicarbonate of soda.

3. When bubbles of gas form in the glass, hold the cardboard tube a short distance from the flame (be careful not to hold it too near!).Tip the glass slowly against the tube, as if you were pouring air from the glass into the tube.

Result

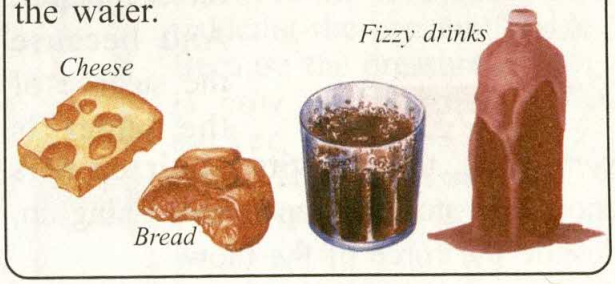
The flame goes out.

Reason

Because the bubbles of gas which you saw forming when the bicarbonate of soda and the vinegar were mixed together are carbon dioxide. This gas is heavier than the air and so goes down along the tube and on to the flame, taking away the oxygen and so interrupting the combustion. Fire extinguishers used to put out other types of fires, such as those arising from faulty electrical appliances, contain carbon dioxide.

CARBON DIOXIDE IN FOOD AND DRINKS

The holes which we see in some cheeses are caused by carbon dioxide which develops as milk curdles and becomes sour. The spongy appearance of bread is due to the bubbles of carbon dioxide which develops as yeast makes the dough rise. Carbon dioxide can also be used to make drinks fizzy. Shake a bottle of fizzy drink, than unscrew the cap. The drink fizzes up out of the bottle! Carbon dioxide gas is dissolved in water in the drink. It is kept under pressure in the bottle. When you unscrew the cap, you reduce the pressure and the gas bubbles up out of the water.



THE PRESSURE OF AIR

DOES AIR EXERT A FORCE?

Air exerts a force of pressure on all surfaces with which it comes in contact.

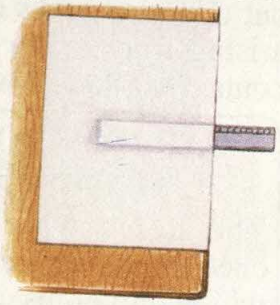
TRY IT YOURSELF

Things you will need

★ A ruler
★ A sheet of paper
★ A board to work on

Directions

1. Place the ruler on the board so that it sticks out over the edge by about one third.

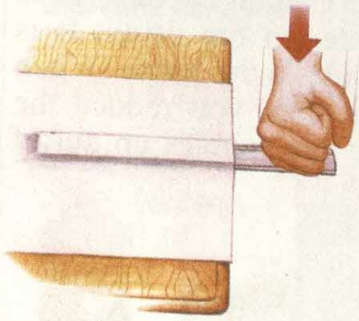


2. Put the sheet of paper on top of the ruler, so that the paper lays flat on the board.

3. Strike the sticking-out part of the ruler to make the paper jump up in the air. (Take care that the blow is not hard enough to break the ruler!)

Result

The paper stops the ruler from lifting up.



Reason

Because air is pressing down on the paper. And because the surface of the paper is very wide, the quantity of air on it is enough to stop the paper from rising up, despite the force of the blow.

Things you will need

★ A bowl ★ A drinking glass ★ Water

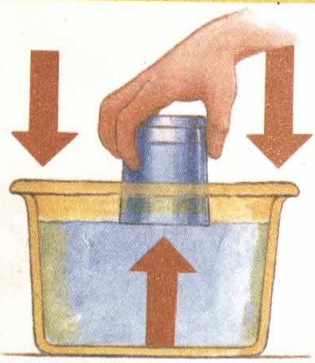
Directions

1. Put the glass into the water and turn upside down.

2. Lift up the glass, but without the rim going above the surface of the water.

Result

The level of water in the glass rises, so that this is higher than the water outside the glass.



Reason

Because the pressure of air on the surface of the water in the bowl pushes the water up into the glass. If the rim of the glass were raised above the surface of the water, air would enter and push the air outside. Then the glass would empty.

THE PRESSURE OF AIR

DOES AIR ONLY PRESS DOWNWARDS ?

Air pressure is exerted in all directions, as well as from the bottom to the top.

TRY IT YOURSELF

Things you will need

- ★ A glass with a smooth rim
- ★ A picture postcard, or a piece of glossy card, postcard size
- ★ Water

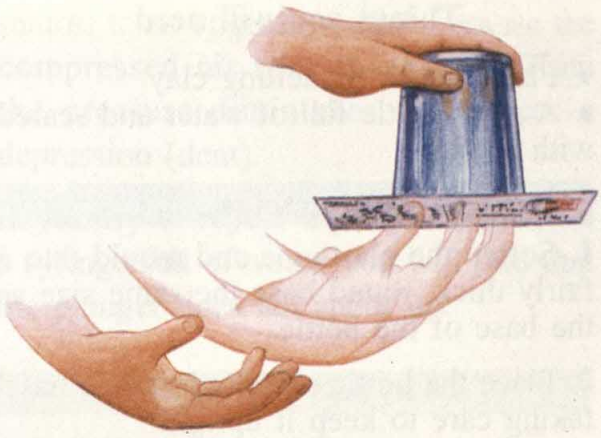
Directions

1. Fill the glass with water.

2. Carefully place the glossy side of the postcard down on the rim of the glass. (You will eventually make it a little bit wet.)

3. Keeping the palm of your hand on the card, turn the glass upside down.

4. Take your hand away from the card.



Result

The card remains attached to the rim of the glass and the water does not fall out.

Reason

Because the air pressure exerted on the card from underneath is greater than the weight of the water inside the glass. This is why the card sustains the water and the water does not spill out.

AIR LIFT

Rubber suction pad work because of air pressure. When pressed against a flat surface, air is forced out, reducing the pressure inside. Because the pressure outside is now much greater, the sucker is pushed firmly down. This experiment shows the pressure is enough to hold a stool in the air.

THE PRESSURE OF AIR

DOES THE AIR WHICH SURROUNDS THE EARTH PRESS DOWN ON US ?

The atmosphere presses down equally on bodies and objects. It is balanced by the pressure of air within them.

TRY IT YOURSELF

Things you will need

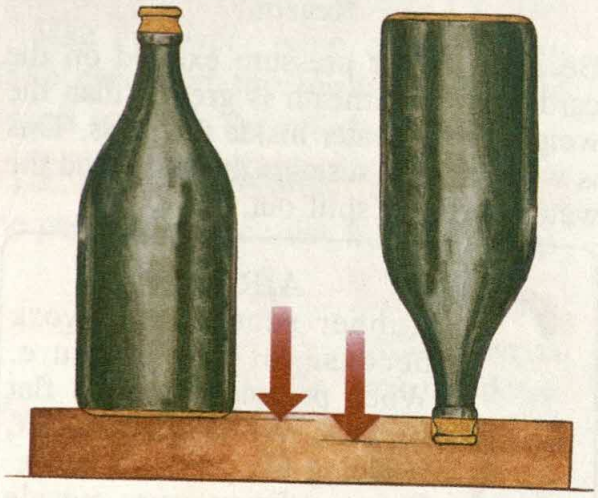
- ★ Plasticine or modelling clay
- ★ A glass bottle full of water and scaled with a cork

Directions

1. Soften the plasticine and mould into a fairly thick, round base the same size as the base of the bottle.

2. Place the bottle on the plasticine base, taking care to keep it upright.

3. Remove the bottle. Turn it upside down and put it on the plasticine base again.



Result

The print left in the plasticine by the upright bottle is not as deep as the print left by the upside down bottle.

Reason

Because the surface on which the weight of the upright bottle is distributed is larger. But with the upside down bottle, the same weight is concentrated on a surface which is smaller. This exerts greater pressure and so the upside down bottle leaves a print which is much deeper. The pressure exerted by a human body also depends on how large the surface of contact is. That is why skis prevent skiers from sinking into the snow.

HIGH AND LOW PRESSURE

We cannot see air, but it is all around us. Gravity pulls the atmosphere down on the Earth. This is air pressure. You do not normally feel this pressure because there is an equal pressure inside your body pushing outwards. At ground level, the pressure is greatest because there is a large weight of air overhead pushing down. The higher you go, the less air there is so the less pressure it exerts. You have to boil an egg longer to cook it at high altitudes because the lower air pressure allows water to boil at a lower temperature. Aeroplanes flying high in the sky have pressurized cabins so that there is enough air to breathe.

THE PRESSURE OF AIR

CAN AIR BE COMPRESSED ?

Air can be compressed; the force of compressed air can support and move considerable weights.

TRY IT YOURSELF

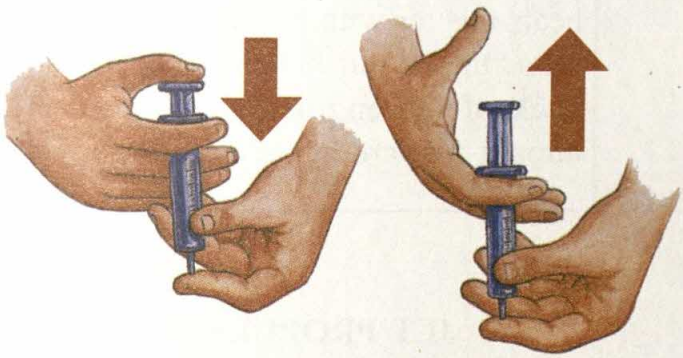
Things you will need

★ A plastic syringe without a needle

Directions

1. Take the syringe and lift the plunger, so that the syringe fills with air.

2. Cover the hole of the syringe with a finger and press down hard with the plunger. Then let it go.



Result

The plunger shoots up, as if by an unseen force. Then it stops : you feel a strong push against your finger. Take your finger away and the plunger returns to its original position.

Reason

Because the air is compressed, because the plunger makes it occupy a much smaller space. This compression increases the air pressure – that is the force with which it presses against the inside of the container and on your finger. The plunger returns to its original position because the compressed air tries to expand. Then the pressure diminishes and makes a depression (dent).

If you try to repeat the experiment with a syringe full of water, you will find that the plunger does not shoot up.

Things you will need

★ String
★ Sticky tape
★ A medium-size balloon
★ Drinking straw

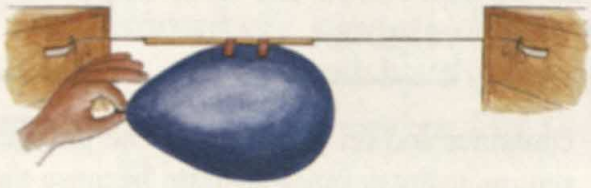
Directions

1. Thread the string through the straw and tie the ends tightly between two points at equal height in a room (e.g. handles or hooks).

2. Inflate the balloon and keep the neck closed between your fingers.

3. Fix the balloon underneath the drinking straw with the sticky tape and

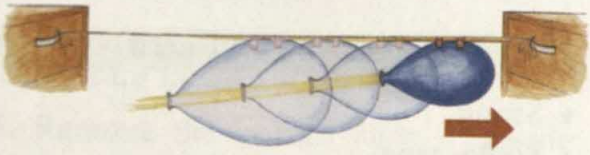
pull the balloon along to one end of the string.



4. Pull your fingers against the mouth of the balloon, then let go.

Result

The balloon shoots along the thread at speed.



Reason

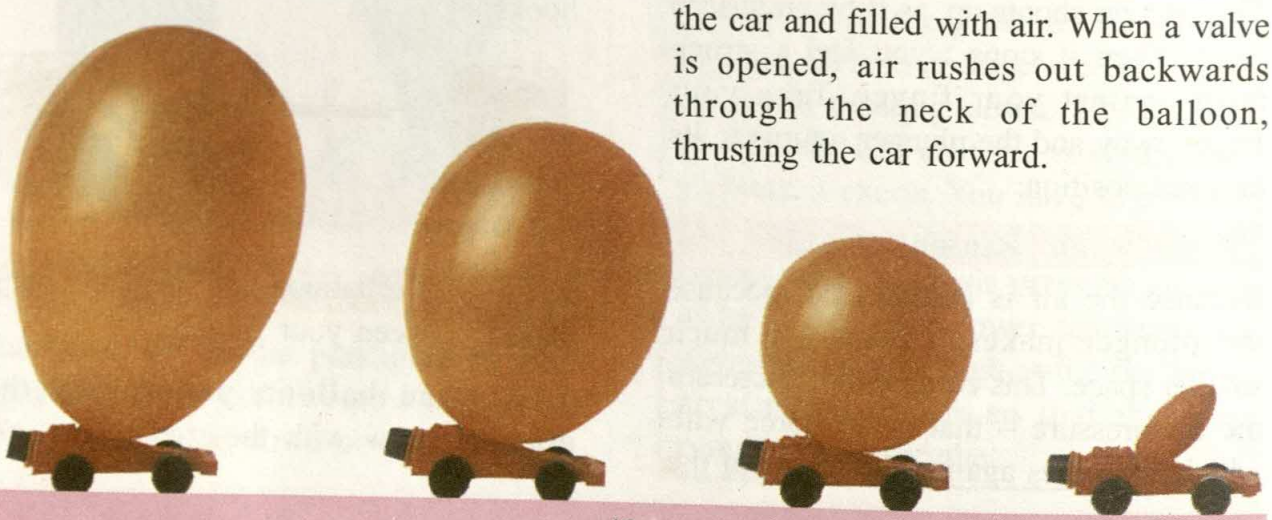
Because when the balloon is closed, the air inside presses equally against the inside surface. When the balloon is let go, the air inside expands. This creates a backward thrust, and the reaction is that the balloon is pushed forward.

JET ENGINES AIRCRAFT

Jet engines power the fastest cars in the world as well as high-speed aircraft. A jet engine sucks in air at the front and heats this air with burning fuel. It then sends the hot air blasting out from the back of the engine. This forces the aircraft forward at very high-speed.

JET PROPULSION

This toy car uses jet propulsion to speed along the floor. A balloon is attached to the car and filled with air. When a valve is opened, air rushes out backwards through the neck of the balloon, thrusting the car forward.



HOT AIR AND COLD AIR

WHAT HAPPENS TO AIR WHICH IS REHEATED ?

When it is hot, air spreads out and so occupies more space than when air is cold.

TRY IT YOURSELF

Things you will need

- A balloon
- An empty bottle
- A basin with hot water. (Take care : hot water must be handled with caution!)

Directions

1. Inflate the balloon slightly and place on the neck of the bottle.

2. Hold the bottle for a minute or two in the hot water.

Result

The balloon inflates.

Reason

Because the air, like all substances, is made up of tiny, moving particles called molecules. The heat makes these molecules move apart. This means that the air inside the bottle spreads and therefore it needs more space. So it enters into the balloon and inflates it.

3. Now run the cold water tap on the balloon.

Result

The balloon deflates.

Reason

Because the air, now affected by the cold, contracts (that is, the molecules come closer together). And so the air occupies only the space in the bottle.

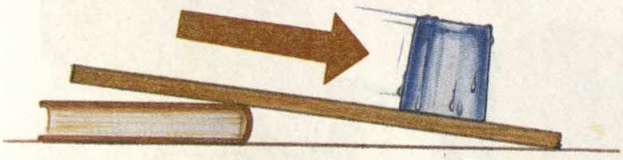
Things you will need

- ★ A glass
- ★ A book
- ★ A board with a smooth surface
- ★ Cold and hot water

Directions

1. Balance the board on the book so that it is slightly tilted. Rinse the glass in cold water and put it upside down on the highest point on the board.

2. Now take the glass and rinse in hot water. Put it once more on the highest point of the board.



Result

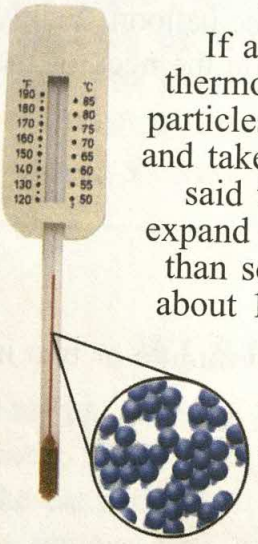
When the glass is rinsed in cold water, it moves slowly towards the bottom of the board, then stops. When the glass is rinsed in hot water, it slides rapidly to the bottom and falls.

Reason

Because the air contained in the glass, heated by the water, expands and the glass rises very, very slightly from the board, so it can slide towards the bottom without any resistance (anything to stop it).

EXPANSION

If an object, like this thermometer, is heated, its particles start to move faster and take up extra space. It is said to expand. Liquids expand about 10 times more than solids. Gases expand about 100 times more than liquids.



Kinetic theory explains how a thermometer works. An increase in temperature causes the alcohol or mercury inside to expand and move them up the scale.

Beware of air expansion !

On any aerosol spray you will find this warning : (keep out of direct sunlight. do not expose to temperatures above 50°C). After the experiments on these pages, you can understand the reason for these words. The gas compressed in the aerosol that we use to spray the product is like air : if it heats up, it will expand and make the aerosol explode !

HOT AIR AND COLD AIR

DOES AIR WEIGH THE SAME AS COLD WHEN IT IS HOT?

Hot air is lighter than cold air and therefore rises up.

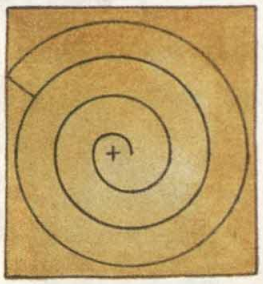
TRY IT YOURSELF

Things you will need

- A square of paper (at least 15cm square)
- A pencil
- Scissors
- A piece of string, about 20cm long
- A square of heat, such as a very hot radiator – or you can use an electric pan under the supervision of teacher or an adult.

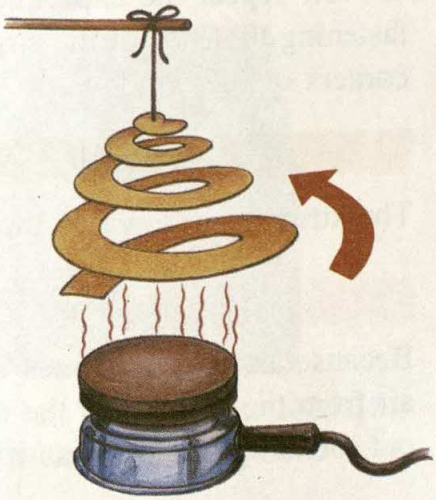
Directions

1. Draw a spiral on the paper as shown in the picture. Cut along the spiral lines.



2. Make a little hole in the centre of the spiral. Thread the string through and fasten with a knot.

3. Hang the spiral above the source of heat.



Result

The spiral begins to spin round on its own.

Reason

Because the air is warmed up by the source of heat and rises up. As it comes in contact with the spiral, the air is channelled between the strips, pressing against them and making it spin round.

HOT-AIR INSIDE

Air molecules inside a hot-air balloon are further apart because they are moving so fast. This means that the hot-air inside the balloon is lighter than the cold-air outside. The hot air inside a hot air balloon is less dense than the colder air of the atmosphere. So the balloon will remain in flight for as long as the air inside it is heated.

HOT AIR AND COLD AIR

HOW DOES HEAT SPREAD IN THE AIR?

In the air heat is transmitted through rising and falling movements called convective currents.

TRY IT YOURSELF

Things you will need

- ★ Tissue paper
- ★ Scissors
- ★ String
- ★ Sticky tape

This experiment must be done in a warm room in water.

Directions

1. Use the sticky tape to stick strips of tissue paper to a piece of long string.

2. With another two pieces of sticky tape, stick the ends of the string to the lower corners of a window, as shown in the picture.

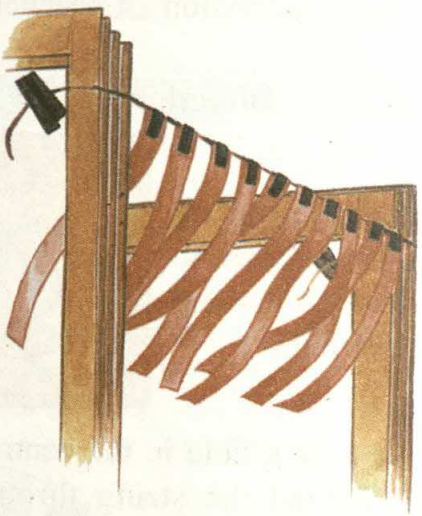
3. Open the window just enough to pull the string tight. Watch the movement of the tissue paper strips.

Result

The strips bend towards the inside of the room.

Reason

Because the cold air which enters, strikes them.



4. Now repeat the experiment, this time fastening the ends of the string to the top corners of the window.

Result

The strips bend towards the outside.

Reason

Because as cold air comes in below, hot air from the top part of the room escapes out, bending the strips as it does so.

HOT AIR AND COLD AIR

Things you will need

- ★ Three glass jars
- ★ Three lids
- ★ Something woollen
- ★ Sheets of newspaper
- ★ A box as deep as the jars
- ★ Hot water
- ★ A thermometer which can be used in water

Directions

1. Wrap the first jar in the woollen material. Put the second jar in the box, and pack crumpled-up newspaper all around it. Leave the third jar uncovered.

2. Fill all three jars with hot water. Take the temperature of each and screw the lids on top.

3. Place the jars somewhere cold (for example a balcony or in a cold room) for 30 minutes.

4. Use the thermometer to check which jars of water have cooled the least.

Result

The water which cooled the most was in the jar that was uncovered. The water which had cooled the least was in the jar inside the box with the crumpled-up newspapers, also the jar wrapped in woollen material.

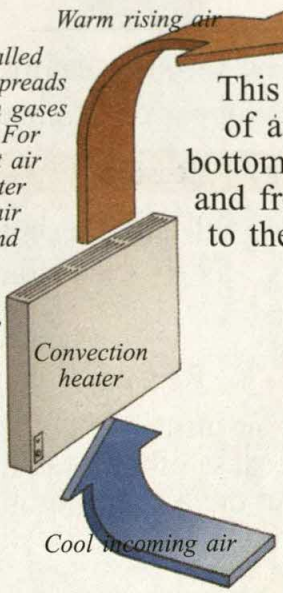
Reason

Because the quantity of air trapped inside those two jars was more, because they were insulated against the cold air. This slowed the cooling down of the water.

CONVECTION

Heat can get through cold and hot things. In a room, a hot radiator warms the air nearby, than the air around it. As the hot air rises, its place is taken by cold air, which is heavier. This air in turn is warmed up and rises. When air is high up, it comes in contact with air which is colder and warms up this air. So the hot air becomes cold again and descends and this hot air-cold air-hot air cycle continues. This movement of air from the bottom to the top and from the top to the bottom is called the convector current.

A process called convection spreads heat through gases and liquids. For example, hot air above a heater rises. Cold air flows into and take its place, becomes hot, and rises. In this way, a circular current of air moves around a room, carrying heat with it.



DOES HOT AIR AND COLD AIR EXERT THE SAME PRESSURE ?

Hot air expands, weighs less and therefore exerts a lower pressure than cold air.

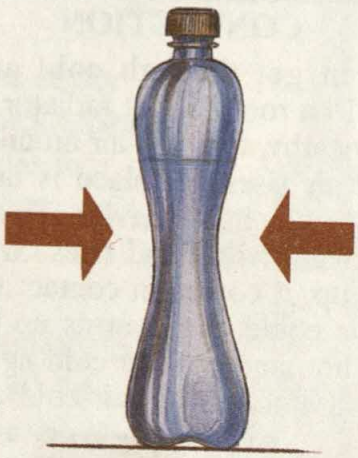
TRY IT YOURSELF

Things you will need

★ An empty plastic 1.5 litre bottle with the stopper
★ Hot water

Directions

1. Fill the bottle with hot water.



2. After a few seconds, empty the bottle and put the stopper on at once.

Result

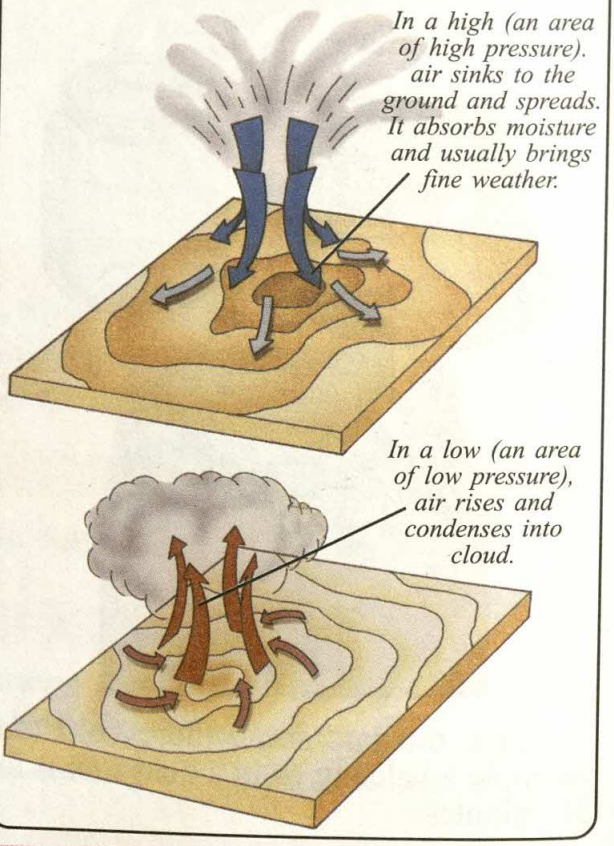
At once you will see the bottle flatten lengthways, as if two hands were squeezing it !

Reason

Because the air inside the bottle, light and expanded because of the heat, has a lower pressure than the air on the outside. It is the pressure of the air outside which squashes the bottle.

HOT AIR AND COLD AIR

Pressure is not the same everywhere. If the air is cold, it sinks, pushing down to create a higher pressure on Earth. As the air is squashed together, it warms up and so brings fine weather. If the air is warm, it rises and so there is a lower pressure on Earth. The warm air may also evaporate water from the sea and take it up to form clouds. This is why low pressure can bring rain.



HOW MUCH FORCE DOES THE WIND HAVE ?

The wind has great strength. This can be used as a source of energy, but it can also have devastating effects.

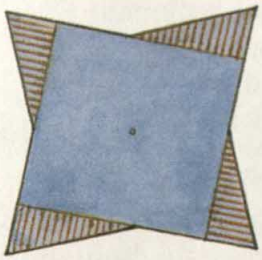
TRY IT YOURSELF

Things you will need

- ★ A piece of cartridge paper
- ★ A pencil
- ★ Scissors
- ★ A drawing pin
- ★ A small stick

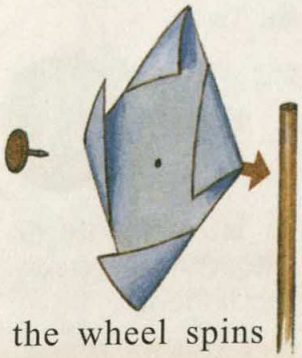
Directions

1. Cut the cartridge paper as shown in the picture.



2. Fold the parts shaded in the picture.

3. Fix the centre of the wheel to the stick with the drawing pin.



4. Make sure that the wheel spins freely. Hold it so that the wind catches it.

Result

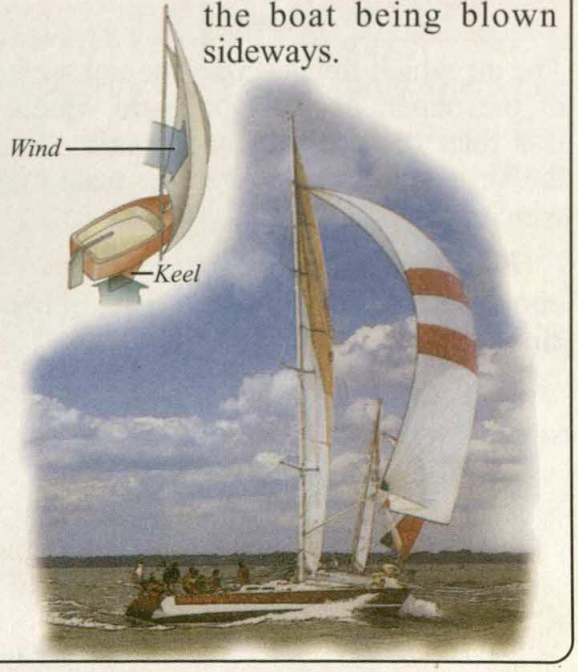
The wheel spins fast.

Reason

Because as the air strikes the card, it is gathered up towards it, but it is stopped at each of the four corners. The thrust of the wind against the four corners pushes the wheel around. Windmills and machines on wind farms work in the same way. Wind blows on to the obstacles that can be pushed, i.e. the sails, making them turn. On wind farms, the energy of the wind is transformed into electrical energy.

WIND FORCES IN SAILING

Sailors can make their boats go in any direction, no matter which way the wind is blowing. This is because two forces combine to produce a result that drives the boat in the required direction: the force on the sails, which depends upon the direction of the wind and the position of the sails; and the force produced by the keel, which stops the boat being blown sideways.



FLIGHT

HOW DOES A WING WORK ?

The wing of an aircraft in flight is sustained by a force called 'lift', caused by the air pressure underneath the aircraft.

TRY IT YOURSELF

Things you will need

★ A strip of paper 10cm wide and 20cm long
★ A sheet of paper
★ Two books

Directions

1. Hold the sheet of paper under your bottom lip and blow on the top surface.

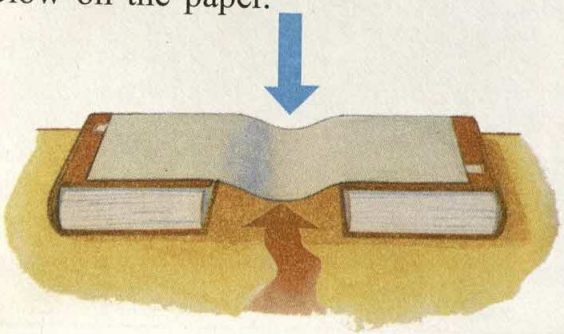
Result

The sheet of paper rises.

Reason

The air which flows across the top surface of the paper, exerts a pressure which is less than the pressure underneath, where the air is still. It is the pressure underneath which makes the paper rise.

2. Place the sheet of paper across two books which are set about 10cms apart. Blow on the paper.



Result

The paper sinks down between the books.

Reason

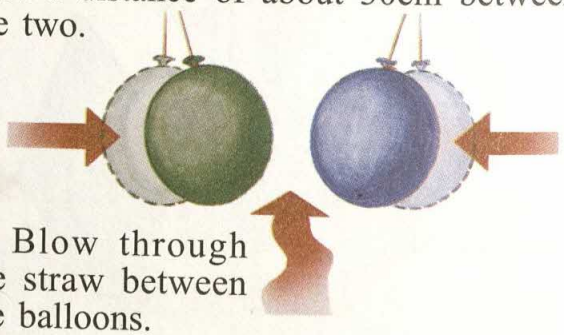
Because the air moving underneath the paper, exerting a pressure which is less than that which presses down on the top surface of the paper.

Things you will need

★ Two balloons
★ Thread
★ A drinking straw

Directions

1. Inflate the balloons and tie the thread around the mouth of each one. Ask someone to hold them in front of you with a distance of about 30cm between the two.



2. Blow through the straw between the balloons.

Result

The balloons come near each other.

Reason

The air is quite still around the outside of the two balloons. This exerts a greater pressure than the air which flows between them, and so it pushes one balloon towards the other.

FLIGHT

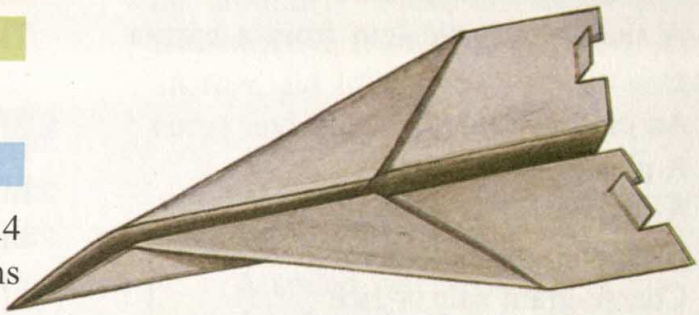
WHICH SHAPE IS BEST FOR FLYING ?

An aerodynamic shape is one which penetrates easily through the air and the air flows quickly over its surface.

TRY IT YOURSELF

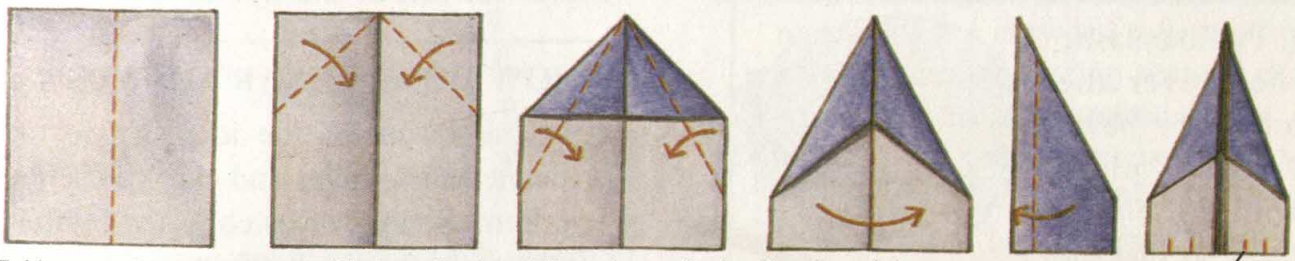
Things you will need

★ Two sheets of A4 paper



Directions

1. Make a paper aeroplane from one A4 by carefully following the instructions underneath each drawing below.



Fold paper along the dotted lines, then open it out.

Fold along the dotted lines shown, in the direction of the arrows.

Make two cuts either side of the centre fold.

2. Throw the flat sheet of paper into the air and watch what it does.

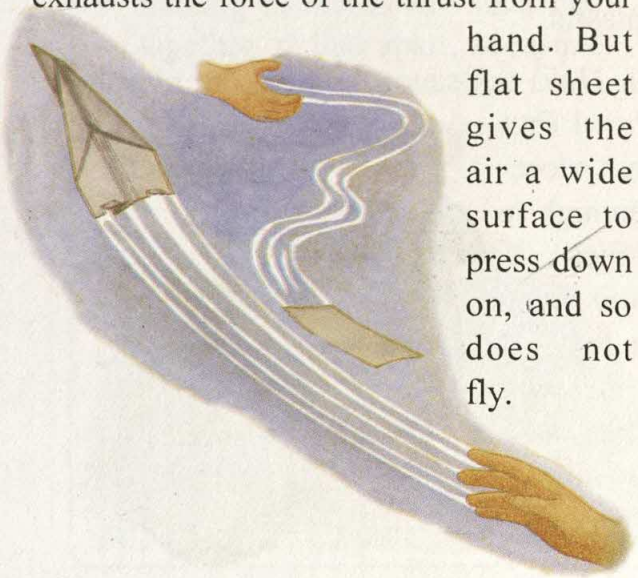
3. Now throw the paper aeroplane into the air, and watch what it does.

Result

The flat sheet of paper flutters haphazardly in the air, and soon falls to the ground. But the paper aeroplane keeps in the air much longer and follows a proper path.

Reason

Because the shape of the paper aeroplane is made to break through the air. It uses the 'lift' to remain in flight, until it exhausts the force of the thrust from your hand. But flat sheet gives the air a wide surface to press down on, and so does not fly.



SOUNDS

HOW DO SOUNDS SPREAD ?

Sounds spread and reach our ear through air which vibrates.

TRY IT YOURSELF

Things you will need

- ★ A sheet of plastic (cut from a carrier bag)
- ★ An elastic band
- ★ A plastic bowl
- ★ A saucepan
- ★ A wooden mixing spoon
- ★ Coarse-grain salt or rice

Directions

1. Put the plastic sheet over the top of the bowl. Keep in place with the elastic band so that the plastic is tightly stretched.

2. Place the salt or the rice on the plastic.

3. Hold the saucepan near the plastic bowl (but not close enough to touch) and hit it a few times with the wooden spoon.

Result

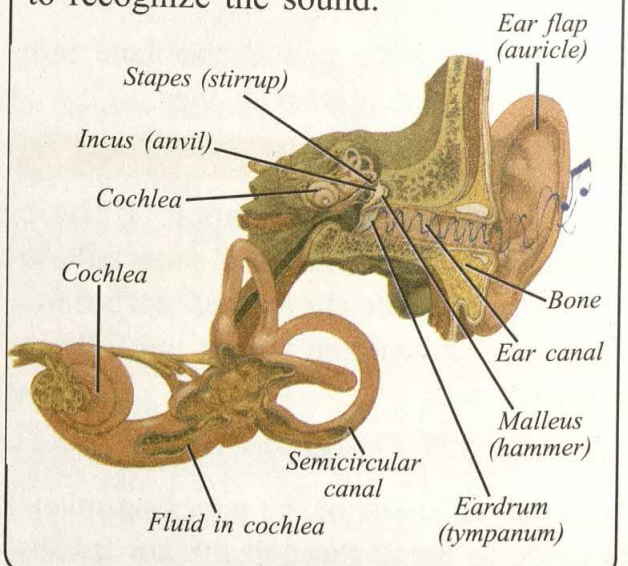
The grains of salt or rice jump about.

Reason

Because when the saucepan is hit, it makes a noise which vibrates. This makes the air around it vibrate as well, producing sound-waves. When these waves hit the bowl, the bowl vibrates and makes the salt or the rice jump about.

HOW DO WE HEAR SOUNDS ?

The human ear is the ideal shape to receive sound-waves and carry these to eardrum. Sound waves collected by the outer ear force the eardrum to vibrate. These vibrations are carried on to the inner ear. These nerves send electrical impulses to the brain, which enables us to recognize the sound.

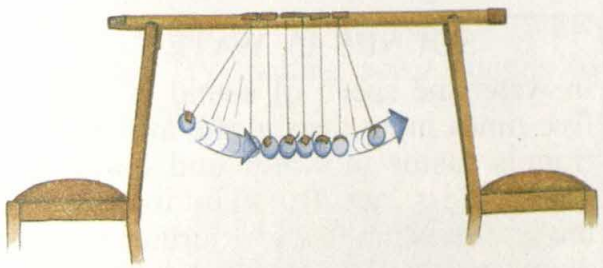


Things you will need

- A broom handle
- Six ping-pong balls
- Six pieces of string, each 50cm long.
- Two chairs
- Sticky tape

Directions

1. Place the chairs back to back. Lay the broom handle across the back of the chairs.



2. Fix a ping-pong ball on each length of string with the sticky tape. Then tape the loose end of each piece of string to the broom handle, so that each ping-pong ball will touch the one on either side.

3. Pull back the first ping-pong ball, so that the string is tightly stretched. Then, let go, so that the ball will touch the next one.

Result

All the balls start moving, the last one in the line swinging as far out as the first.

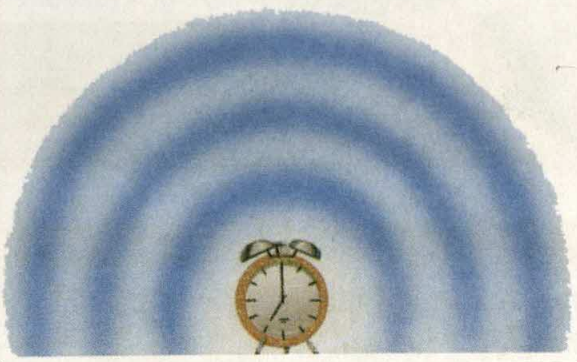
Reason

Because the first ball passes on the movement to the second, which transmits the movement to the third, and so on. Air molecules which are hit by sound vibrations behave in the same way.

Vibrations from an object spread into the air around it. These vibrations are then transmitted from one layer of air to another, due to the way a sound-wave can curve and bend.

SOUND WAVES

A sound wave consists of air molecules vibrating backward and forward. At each moment the molecules are crowded together in some places, producing regions of high pressure, and spaced out in others, producing regions of low pressure. Waves of alternately high pressure and low pressure move through the air, spreading out from the source of the sound. These sound waves carry the sound to your ears. A sound spreads, the molecules making of the air are squashed together, pulled apart, squashed again, and so on, making sound waves.



SOUNDS

ARE SOUNDS TRANSMITTED ONLY THROUGH THE AIR ?

Sounds can also be transmitted through solids and liquids more quickly than through the air.

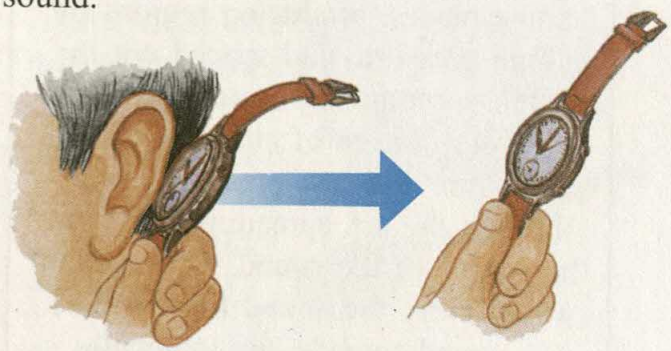
TRY IT YOURSELF

Things you will need

- ★ A wrist watch
- ★ A table

Directions

1. Hold the watch to your ear and listen to the ticking. Then gradually move it away until you can no longer hear the sound.



2. Place the watch on the table. Put your ear on the table at the same distance which you measured first.

Result

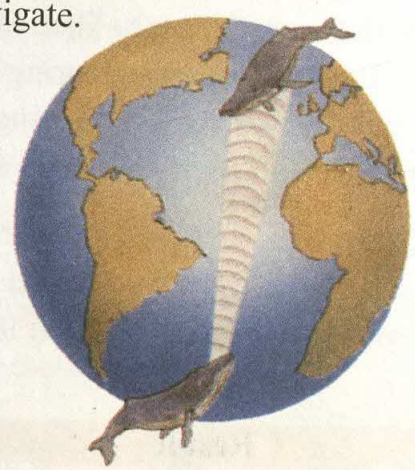
The ticking of the watch is distinctly heard by your ear.

Reason

Because sounds are better transmitted through solids than through the air. Sounds also travel easily through bricks and glass. That is why sounds can be heard through walls and windows.

SOUNDS IN WATER

In water the speed of sound is almost five times more than in the air! Sound travels faster in water and loses its energy less rapidly than in air, so underwater sounds travel further before dying away. Whales and dolphins use underwater sounds to communicate and to navigate.



Sounds underwater seem louder. When you swim on your back and your ears are under the surface of the water, you will hear the sound of your breathing louder (amplified); if you try to beat two stones in water you will hear the sound they make very strongly.

HOW DO STRING INSTRUMENTS WORK ?

Instruments with strings have a space for resonation, in which the air vibrates, amplifying the sound.

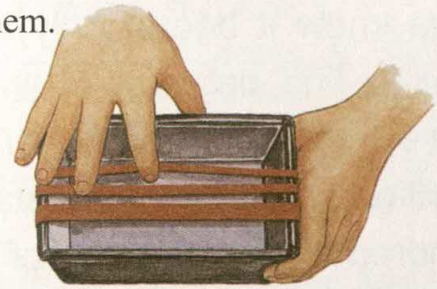
TRY IT YOURSELF

Things you will need

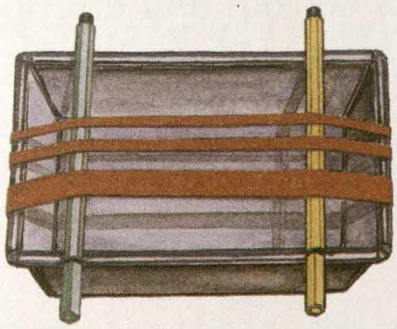
- An aluminium dish
- Elastic bands of various thicknesses
- Two pens

Directions

1. Put the elastic bands around the length of the dish at about 1cm between each one. Try making some sounds by plucking them.



2. Now insert the two pens under the elastic bands, one at each end of the dish. Pluck the elastic bands again.



Result

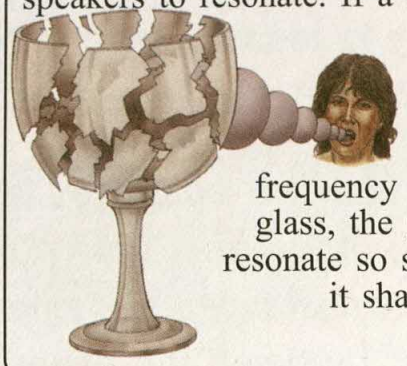
When you plucked the elastic bands the first time, the sounds you heard were rather flat and not very clear. The second time, the sounds were much clearer.

Reason

Because the first time, the vibrations of the elastic bands were obstructed by the bands rubbing against the edges of the dish. But the pens acted like the bridge of a guitar, keeping the elastic bands raised up, so that they vibrated more easily. The bands produced vibrations by resonating the air in the dish, making sounds which were clearer and deeper. The effect of resonation is also used by instruments such as violins, mandolins and pianos, all of which have a space which resonates with vibrating sound.

DANGEROUS RESONATION

Most objects can vibrate. The frequency at which an object vibrates naturally is called its resonant frequency. If a sound of exactly that frequency is played near the object, it picks up energy from the sound wave and vibrates in sympathy. This is resonance. You can often hear resonances when you play loud music in a room. A particular note will cause a door panel or an object near the speakers to resonate. If a singer sings with a frequency equal to the natural frequency of a wine glass, the glass may resonate so strongly that it shatters.



CHEMISTRY

Chemistry is the study of materials.....solids, liquids and gases. A chemist finds out what things are made of and how they are joined together. If a piece of wood is burned in a fire, this is a chemical reaction. The wood turns to ash, and at the same time, heat and light are given off. It took chemists a long time to find out that burning is the joining together of the wood with the gas oxygen from the air. There are lots and lots of chemical reactions.

The true science of chemistry as we know it began only in the 1600s. Chemists at this time began to find out how chemicals really work. Then they discovered the elements, simple substances which make up all the millions of different substances on earth. There are only about a hundred elements, each of them made up of tiny *"atoms"*. The atoms of elements often join together to make different substances. The salt you put in your food is made up of atoms of the elements sodium and chlorine. An atom of sodium joins with an atom of chlorine to make a molecule of salt, like this.

Chemistry is today a very important science, and chemists are employed in a vast number of industries.

You will find the answeres about *"solids, liquids and gases, mixtures, solutions and compounds, chemical reactions, analysing substances and chemistry around us and many more questions"* by doing the experiments in this section.

SOLIDS, LIQUIDS AND GASES

DOES HEAT CHANGE A SUBSTANCE ?

Solids, liquids and gases can dilate (enlarge) with the effect of heat.

TRY IT YOURSELF

Things you will need

★ Three identical glass jars with stoppers
★ Scissors
★ Three thin glass tubes, about 20-30cm long
★ Plasticine and sticky tape
★ Water, olive oil, methylated spirit
★ A rectangular oven-dish
★ A saucepan

Directions

1. Fill one jar with water, the second with oil, the third with methylated spirit. Label the jars with a sticky tape.

2. Make a hole in the centre of each stopper. Push the glass tubes through, each one to the same depth in the jar, but not touching the bottom. Put plasticine around the tube at the top to hold it firmly.

3. Pour water into the oven-dish. Stand the three jars in the water. Ask an adult to put the oven-dish on the hot-plate.

Result

In a little while, the level of water in the three jars rises at different levels according to the substance.

Reason

The heat of the water in which the jars stand causes the dilation (enlargement or spreading) of the liquid they contain. (Dilation varies according to the density of each liquid.) There is not enough space inside the jars for the spread of the liquid, and so it rises up into the glass tubes.

Things you will need

★ A coin ★ A length of iron wire ★ A clothes peg ★ A lit candle

Directions

1. Make a ring from the wire. This must be of the same diameter as the coin, so that the ring goes exactly over the coin.

2. Grip the coin with the clothes peg. Hold it over the flame of the candle for a few minutes.

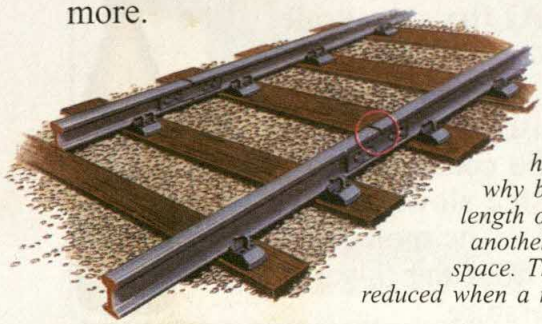
3. Now try to thread the ring over the coin again.

Result

The coin no longer passes through.

Reason

Because the heat of the flame has temporarily dilated (enlarged) the coin. If you leave it to cool down, you will be able to thread it through the ring once more.



Railway lines can dilate because of excessive heat. That is why between one length of track and another, there is a space. This space is reduced when a railway line dilates.

SOLIDS, LIQUIDS AND GASES

HOW DOES MATTER REACT TO COOLING ?

With the exception of water, when things become cold, they undergo a contraction (become smaller.)

TRY IT YOURSELF

Things you will need

★ A glass bottle ★ A balloon
★ A sink with hot and cold water

Directions

1. With the help of an adult, pour very hot water into the bottle.

2. After a few minutes, empty the bottle. Put the neck of the balloon over the top of the bottle at once.

3. Pour very cold water on the outside of the bottle.

Result

The balloon sinks inside the bottle.

Reason

Because the hot air inside the bottle contracts (shrinks) when it is cold, which means that it reduces in volume. As the air outside enters into the bottle and occupies the space which is left, it also pushes the balloon to the inside. The contraction of the air is due to the slowing-down of the speed of its molecules, resulting from the lowering of the temperature.

Things you will need

★ Some cubes of ice ★ A meat tenderizer
★ A table napkin ★ A plastic bottle with a screw-top

Directions

1. Put some ice cubes in the napkin. Ask an adult to crush the cubes with the meat tenderizer.

2. Put the crushed ice cubes in the bottle. Put the screw-top on.

3. Shake the bottle, so that the inside is thoroughly chilled. Then put it down.

Result

The bottle curls up.

Reason

Because inside the bottle, the ice causes a rapid reduction of temperature of the air. This means that the air inside is reduced in volume. The air outside presses down on the bottle and squashes it.

SOLIDS, LIQUIDS AND GASES

CAN SUBSTANCES CHANGE THEIR PHYSICAL STATE ?

Variations in temperature or pressure can cause the passage of a substance from one physical state to another.

TRY IT YOURSELF

Things you will need

★ An ice cube ★ Half a bar of chocolate
★ A radiator ★ A hot-plate ★ A saucepan
★ Two small plates

Directions

1. Pour a little water in one plate. Place the ice cube in the other plate.

2. Place the two plates on the radiator.

3. Put the chocolate in the saucepan. With the help of an adult, heat it up gently on the hot-plate.

Result

After a few hours, the water disappears. But in a short time, the ice has changed into water. And on the hot-plate, the chocolate melts and changes into a thick liquid.

Reason

Because the heat of the radiator makes the water evaporate. This means that the molecules increase their speed, spreading away from each other and dispersing among the molecules of the air in the form of water vapour. The heat of the radiator also transforms the ice, which is water in its solid state. In the same way, the heat of the hot-plate makes the chocolate change from its solid state to liquid.

THE EFFECTS OF PRESSURE

As well as temperature, pressure also influences the passage of a substance from one state to another. When pressure is increased, this makes the molecules stay close and tied to each other. In the pressure cooker the steam which is created inside pushes on the surface of the water. As a result, the water reaches boiling point at a higher temperature and the food gets cooked more quickly.

DO SUBSTANCES CHANGE IN MIXTURE ?

Substances which form a mixture do not change and can be easily separated.

TRY IT YOURSELF

Things you will need

★ Fine salt ★ White flour ★ A spoon
★ Blotting paper ★ A funnel ★ A jug
★ A large see-through container

Directions

1. In the jug, mix together an equal quantity of fine salt and white flour.

Result

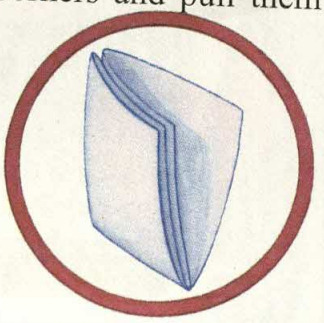
In the mixture, the two substances, flour and salt, cannot be distinguished, one from the other.

2. Pour water into the jug. Mix again. Then wait a little while.

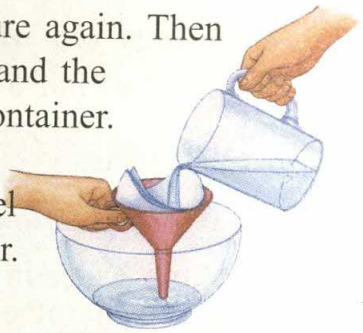
Result

After a few minutes, the flour settles on the bottom of the jug.

3. Fold the blotting paper into quarters. Take three of the corners and pull them back together. Pull the fourth corner back in the opposite direction, to make a filter. Now put the base of the filter in the funnel.



4. Stir the mixture again. Then hold the funnel and the filter over the container. Pour the water through the funnel into the container.

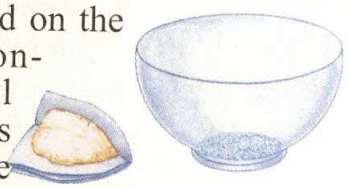


5. Take the filter out of the funnel. Leave the filter to dry.

6. Put the container with the filtered water in a cold place. Wait until the water evaporates.

Result

Flour has gathered on the filter. In the container, when all the water has evaporated, there remains a thin layer of salt crystals.



Reason

Because flour does not dissolve in water. Instead, it tends to separate from it and settles on the bottom. This phenomenon is called decantation. Also, the particles of flour are too big to pass through the blotting paper, so that they stay on the filter. This system of separation from substances is called filtration. The salt has also dissolved in the water. It remains dissolved until the heat makes the water evaporate. Then, the salt returns to its solid state in the form of crystals. This method of separation of the components of a solution is called crystallization.

CHEMICAL REACTIONS

WHY DO NAILS GO RUSTY ?

In the chemical reaction of oxidization, the oxygen bonds with the iron, creating a new substance – iron oxide, or rust.

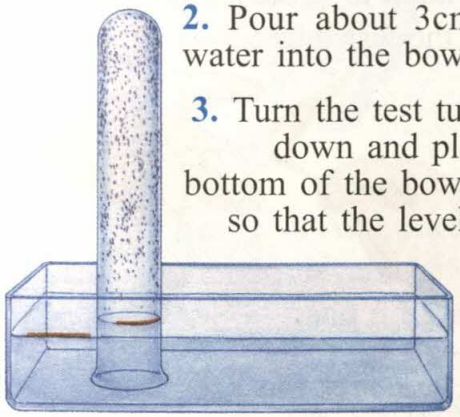
TRY IT YOURSELF

Things you will need

★ Iron filings ★ Test tube ★ A see-through bowl ★ A pen which can write on glass ★ Water

Directions

1. Dampen the inside of the tube. Then shake in a few iron filings, so that they stick to the inside.



2. Pour about 3cm of cold water into the bowl.

3. Turn the test tube upside down and place at the bottom of the bowl. Do this so that the level of water inside the test tube is level with that inside the bowl. (To do this, tip the test tube just a little as you place it in the water.)

4. Use the pen to mark the level of the water, both on the test tube and on the bowl. Then leave the experiment for two days.

Result

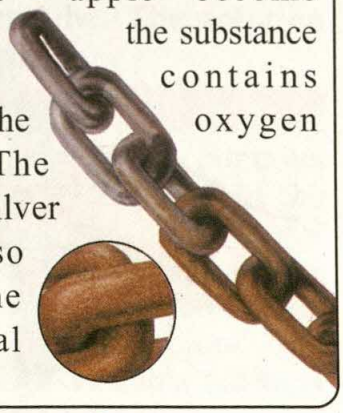
The iron filings become brown. The level of water in the test tube has risen. The level of water in the bowl has gone down.

Reason

The iron, by combining with the oxygen in the air inside the test tube, has formed rust. The chemical name for rust is iron oxide. In this chemical reaction, which we call oxidization, the oxygen has left the air and clustered on the iron. This means that the air inside the test tube has diminished in volume. The air outside presses on the surface of the water in the bowl, pushing it up inside the test tube, so that this occupies the space left by the oxygen.

REACTIONS OF OXIDIZATION

The rust which forms on iron objects deeply corrodes (eats into) those objects, making them weaker. Once rust has formed it remains on the object, making it crumble and exposing the layers of metal underneath to the air. These layers also become oxidized, (forming rust) in their turn. Another example of the reaction of oxidization is when slices of apple become brown, because the substance which the apple contains combines with the oxygen in the air. The blackening of silver things is also caused by the same chemical reaction.



DO CHEMICAL REACTIONS CHANGE COMPOUND ?

Chemical reactions can separate, unite or combine differently the elements of a compound.

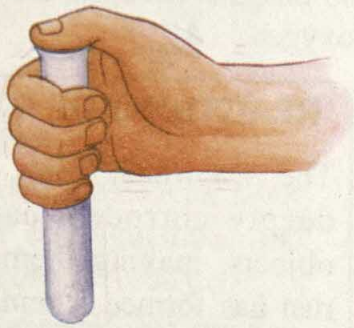
TRY IT YOURSELF

Things you will need

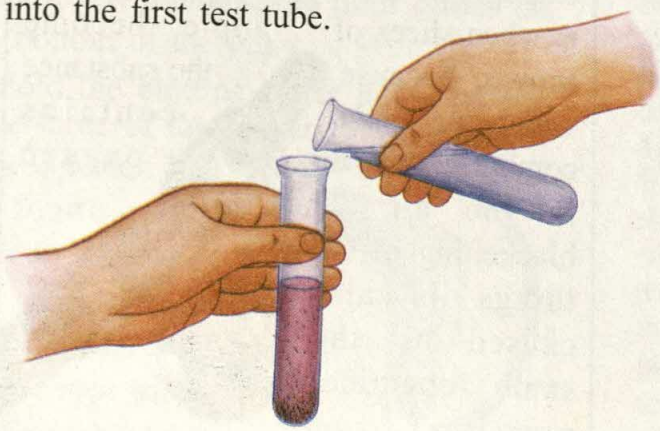
- ★ Iron filings
- ★ Copper sulphate
- ★ Two test tubes
- ★ Hot water
- ★ Vinegar
- ★ A match

Directions

1. Pour some hot water into the test tube. Add a little copper sulphate. Shake the test tube to mix the two substances.

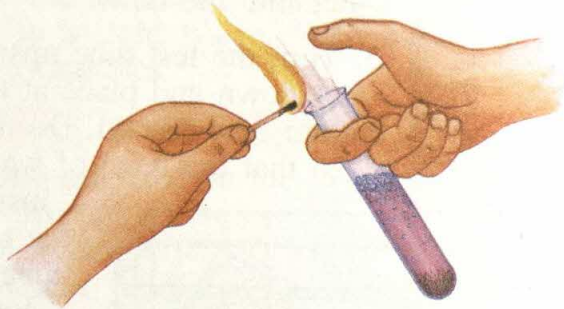


2. Put some iron filings in the other test tube. Then half fill with vinegar. Carefully put two drops of this solution into the first test tube.



3. When you see bubbles forming, close the test tube with your thumb.

4. Ask an adult to strike a match near the mouth of the test tube.



5. When you feel the pressure of gas inside the test tube, remove your thumb.

Result

The flame makes a little bang.

Reason

Because one of the components of vinegar is hydrogen, a gas. When the hydrogen reacts with iron, vinegar and copper sulphate, it is set free and remains isolated. So when the hydrogen escapes from the test tube, the match makes it burst into flame with a little bang and there is a brief increase in the flame.

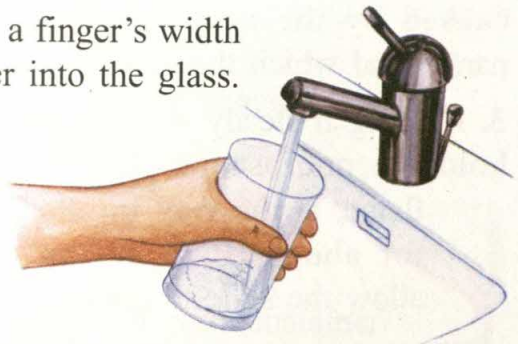
CHEMICAL REACTIONS

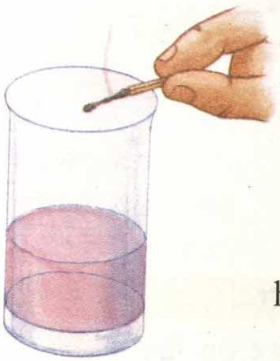
Things you will need

- Bicarbonate of soda
- A teaspoon
- Vinegar
- Water
- A glass, tall and straight, if possible
- A match

Directions

1. Pour a finger's width of water into the glass.





2. Add a teaspoon of bicarbonate of soda and a little vinegar.
3. Ask an adult to light a match and to hold it down into the glass.

Result

The flame goes out.

Reason

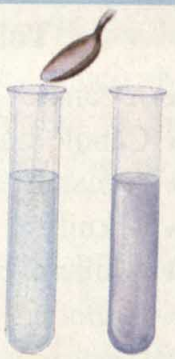
Because the bicarbonate of soda is a compound of sodium, hydrogen, carbon and oxygen. In the chemical reaction, it breaks up in contact with the vinegar. The carbon and oxygen separate from the other elements. Together they form a gas, carbon dioxide, which puts out the flame.

Things you will need

- A test tube
- Water
- Copper sulphate
- Iron filings

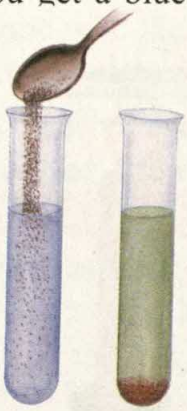
Directions

1. Fill two thirds of the test tube with water.
2. Add the copper sulphate.



Result

You get a blue solution.



3. Add the iron filings. Gently shake the test tube, keeping it closed with your finger.

Result

A red-coloured substance settles on the bottom of the test tube. The solution becomes clear green.

Reason

Because the copper sulphate contains sulphur and copper. When you add the iron filings, the iron and the copper change places. The iron bonds to the sulphur, forming iron sulphur, which gives the solution a green colour. The copper remains isolated and this settles at the bottom of the test tube.

IS COMBUSTION A CHEMICAL REACTION ?

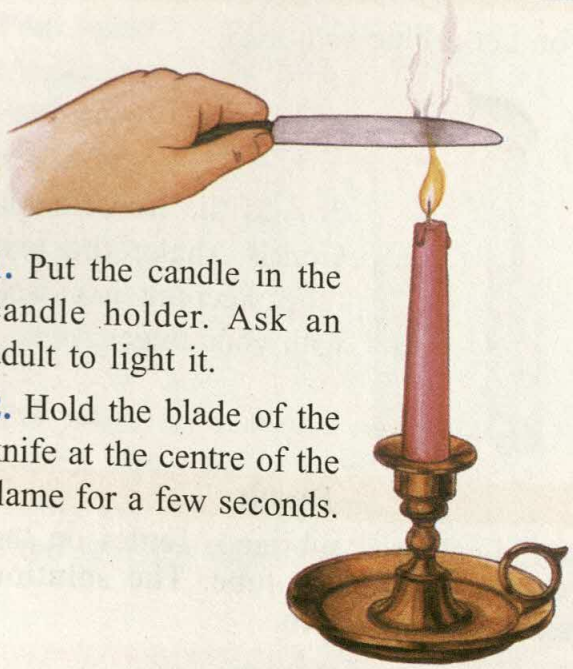
Combustion is a chemical reaction. When a substance burns, it changes and originates new substances.

TRY IT YOURSELF

Things you will need

- ★ A candle
- ★ Candle holder
- ★ A match
- ★ A knife
- ★ A microscope slide
- ★ A clothes peg

Directions

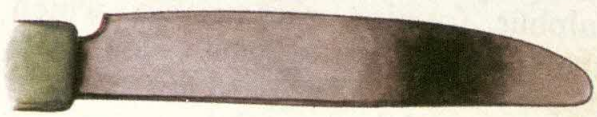


1. Put the candle in the candle holder. Ask an adult to light it.

2. Hold the blade of the knife at the centre of the flame for a few seconds.

Result

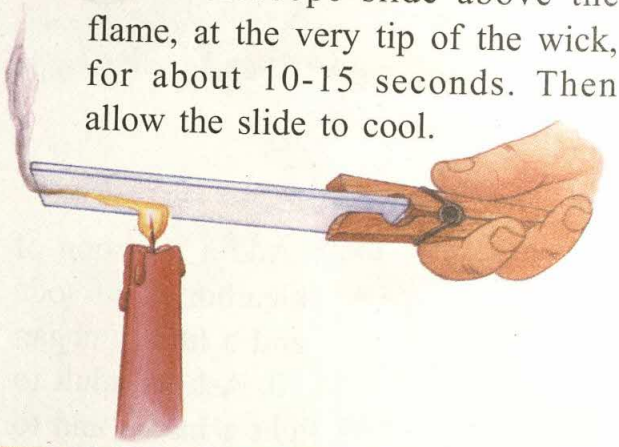
The blade is covered with soot, tiny particles of carbon.



Reason

Because these particles are found in the most central part of the flame. They are caused by the decomposition of the paraffin of which the candle is made.

3. Holding it steady with a clothes peg, hold the microscope slide above the flame, at the very tip of the wick, for about 10-15 seconds. Then allow the slide to cool.

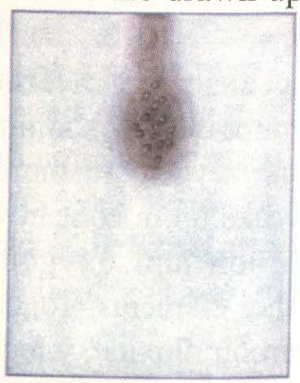


Result

There are traces of wax on the slide.

Reason

Not all the wax decomposes when the flame burns. Some particles are drawn up by the rising heat. On contact with the surface of the slide, these particles clot together again.



CHEMICAL REACTIONS

CAN ELECTRICITY CAUSE A CHEMICAL REACTION ?

The passage of electrical current can break up water as well as the substances dissolved in it.

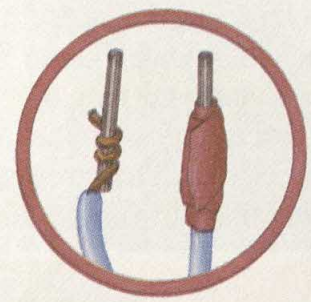
TRY IT YOURSELF

Things you will need

- One 4.5 volt battery
- 2 pieces of electrical cable, with the plastic stripped off the ends (ask an adult to do this for you.)
- The lead from a pencil
- Sticky tape
- Two test tubes
- Vinegar
- Water
- A see-through glass container
- Two clothes pegs
- Matches

Directions

1. Break the pencil lead into two. Wind one end of wire around each battery contact. Wind each free end of wire around the pieces of lead. Wrap the join with sticky tape to hold firm, as shown in the picture. You have now made two electrodes.



2. Fill the container with water. Put in the two electrodes, so that they touch the bottom. Fix the electric cable to the edges of the container with the two clothes pegs.

3. Fill the test tube with water, and hold your finger over the top. Turn the tube upside down into the container. Then take away your finger, so that you can put the tube over the top of the electrode. Do the same with the other test tube and put the second electrode in place.

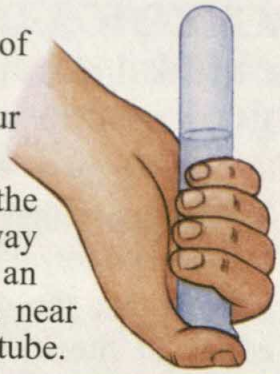
4. Pour vinegar into the container. Then wait for a few hours.

Result

Bubbles have formed in the test tubes. After a few hours, the level of water inside the test tubes has risen.

5. Disconnect the wire ends from the battery.

6. Take the test tube with the lowest level of water out of the container, keeping your thumb over the top.

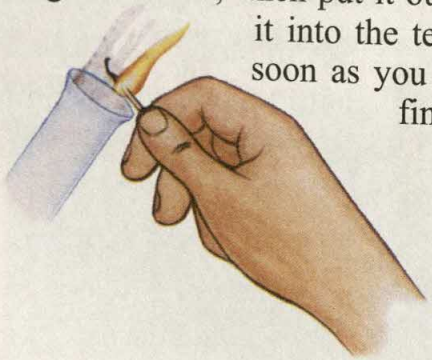


7. Turn the test tube the right way up. Take away your thumb and ask an adult to hold a match near the mouth of the test tube.

Result

There is a little bang.

8. Now take the other test tube from the container in the same way. Ask an adult to light a match, then put it out, and put it into the test tube as soon as you take your finger away.



Result

The match bursts into flame again.

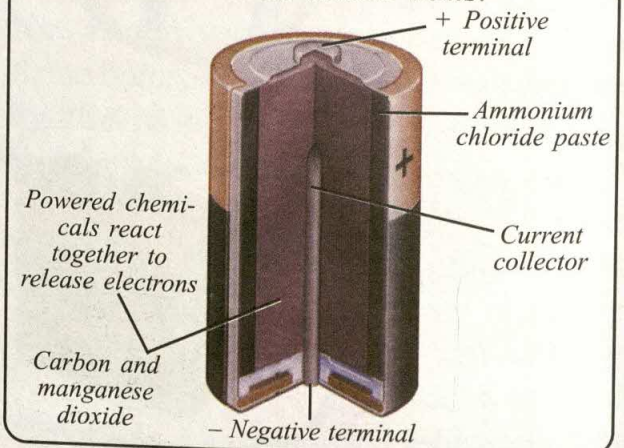
Reason

Because the first test tube contains hydrogen, which with the heat of the flame, explodes. The second test tube contains oxygen, which is able to reactivate the combustion of the match (makes it burn) once again. The passage of electricity (provided by the battery) has caused a chemical reaction in which the components of water, hydrogen and oxygen, are separated. This process is called electrolysis and is also used to separate the compounds dissolved in water.

CHEMICAL REACTIONS CAN GENERATE ELECTRICITY

Inside the batteries which we use to power toys and electrical equipment is a chemical substance called ammonium chloride paste. When the metal cap of the battery touches the metal tabs in a battery compartment, a chemical reaction begins inside the battery and it is this which generates electricity. Little by little, as the current is produced, the ammonium chloride paste is used up and the battery is finally exhausted.

Connecting a battery in a circuit makes the chemicals inside react to produce an electric current. The battery provides a force which pushes electrons around the circuit. The strength of this force is measured in units called volts.



CHEMICAL REACTIONS

DO CHEMICAL REACTIONS PRODUCE HEAT ?

During some chemical reactions the energy contained in the reactants are set free in the form of heat.

TRY IT YOURSELF

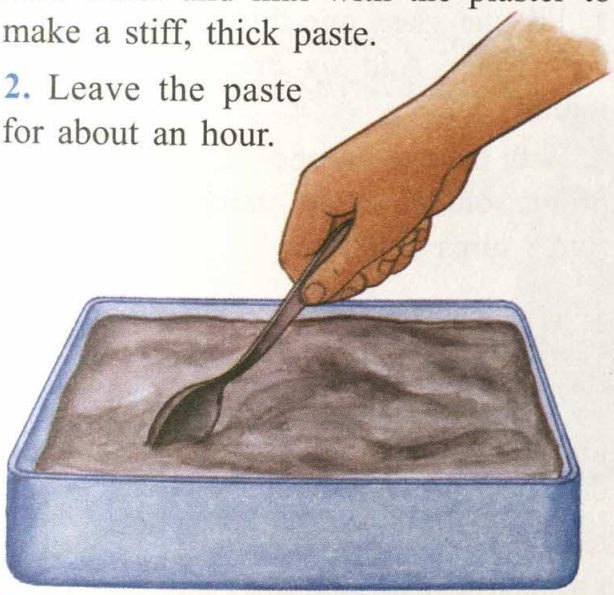
Things you will need

★ Plaster powder
★ Water
★ A deep plastic tray
★ A spoon

Directions

1. Empty the plaster powder into the tray. Add water and mix with the plaster to make a stiff, thick paste.

2. Leave the paste for about an hour.



Result

The plaster hardens and the sides of the plastic tray become hot.

Reason

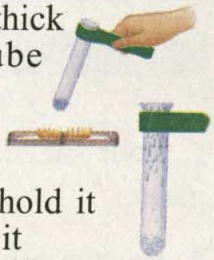
Because the process of hardening of the plaster is due to the chemical reaction of the plaster powder with the components of water. One of the products of this reaction is heat.

Things you will need

★ Copper sulphate crystals ★ A test tube
★ Water ★ A hot-plate ★ An eye-dropper
★ A piece of paper

Directions

1. Fold the paper into a thick strip to make a test tube holder.



2. Put some copper sulphate crystals into the test tube. Ask an adult to hold it over the hotplate, holding it carefully with the paper holder.

Result

The crystals become white. Drops of water form in the upper part of the test tube.

3. Leave the test tube to cool. Then add two drops of water.

Result

The crystals turn blue and the test tube heats up.

Reason

Because the copper sulphate crystals contain molecules of water which, with the effect of heat, evaporate and make the crystals lose their blue colour. When you add water again, the water molecules return to the crystals. This chemical reaction, reversing the result before, comes from the same amount of heat which was absorbed before.

ANALYSING SUBSTANCES

IS IT POSSIBLE TO DISCOVER ONE SUBSTANCE PRESENT IN ANOTHER ?

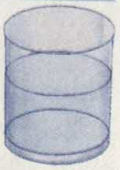
Some substances change colour when they come into contact with others, and this reveals their presence.

TRY IT YOURSELF

Things you will need

★ Lime water (obtainable from a pharmacy or a shop which stocks chemical products) ★ A drinking straw ★ A glass ★ A bicycle pump

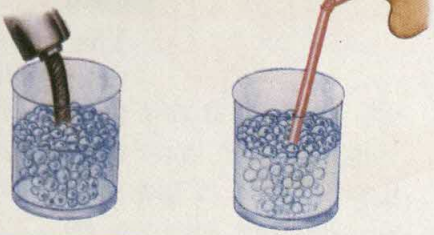
Directions



1. Pour the lime water into the glass.

2. Put the tube of the bicycle pump into the glass. Pump in a little air.

3. Now put the straw into the glass. Blow into the water.



Result

When the pump gives off air into the water, bubbles form, but the lime water remains clear. But when you blow into the water, it becomes cloudy.

Reason

Because the lime water becomes cloudy when it comes into contact with carbon dioxide. This shows that this carbon dioxide (a compound) is present in the air which we breathe out, but not in the air which comes from the bicycle pump. In the process of breathing, we inhale pure air, but breathe out mostly carbon dioxide.

Things you will need

★ Samples of bread, rice, pasta, meat, an apple, a potato, white flour ★ Tincture of iodine ★ Water ★ A glass ★ An eye-dropper ★ Starch powder ★ Seven little plates

Directions

1. Fill the glass one third full with water. Add six drops of iodine.

2. With the eye-dropper, add a few drops of this solution on the starch powder. The starch turns blue.

3. Set out each food sample on a plate. Dampen each one with water. Using the eye-dropper, add a few drops of the water and iodine solution.

Result

Some of the food has turned blue where you added the iodine solution.

Reason

Because the blue colour is the sign that in some of the foods there is starch. This is a sugar very common in vegetables, which they produce and store in seeds and in roots. The iodine solution works as a 'discloser'.

WHAT IS THE PURPOSE OF CHEMICAL ANALYSIS ?

Indicators used in chemical analysis reveal characteristics which are not immediately obvious in substances.

TRY IT YOURSELF

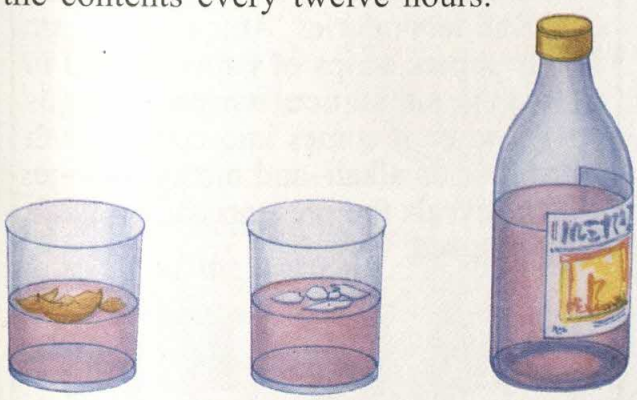
Things you will need

- ★ An egg shell
- ★ Flakes of wall plaster
- ★ Vinegar
- ★ Two glasses

Directions

1. Put the egg shell into one glass. Put the flakes of plaster into the other glass.

2. Half fill each glass with vinegar. Check the contents every twelve hours.



Result

First the egg shell and then the flakes of wall plaster dissolve in the vinegar.

Reason

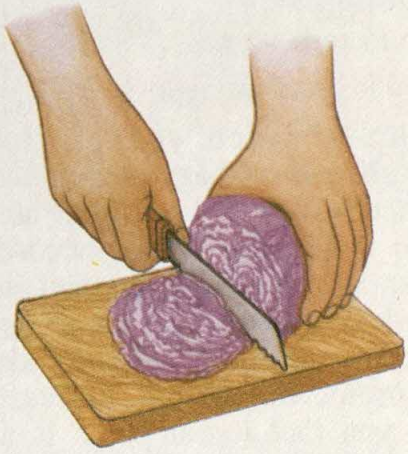
Because the vinegar is a substance which in chemistry is defined as an acid. This means it is able to corrode (eat away) at some substances, such as calcium, which is a component both of the egg shell and the plaster.

Things you will need

- ★ Half a red cabbage
- ★ A knife
- ★ A saucepan
- ★ A hot-plate
- ★ Water
- ★ A strainer
- ★ A glass jar
- ★ Three glasses
- ★ A lemon
- ★ Bicarbonate of soda
- ★ A spoon

Directions

1. Ask an adult to cut the red cabbage into thin slices. Put these in the saucepan and cover with water. Place on the hot-plate to cook.



2. When the water begins to boil, stir the cabbage, then turn off the heat and leave for half an hour.

3. Put the strainer on the jar. Pour the cabbage into the strainer, so that the water filters through into the jar. You now have a liquid indicator.

4. Pour some water with the juice of a lemon into a glass. In another glass pour water with bicarbonate of soda. In the third glass pour plain water.

5. Add a spoonful of the liquid indicator to each glass.

Result

The water with the lemon goes red. The glass containing water with bicarbonate of soda takes on a colour between blue and green. The plain water is only just slightly tinged with the same colour as the liquid indicator.

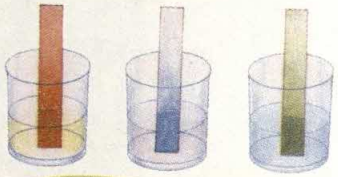
Reason

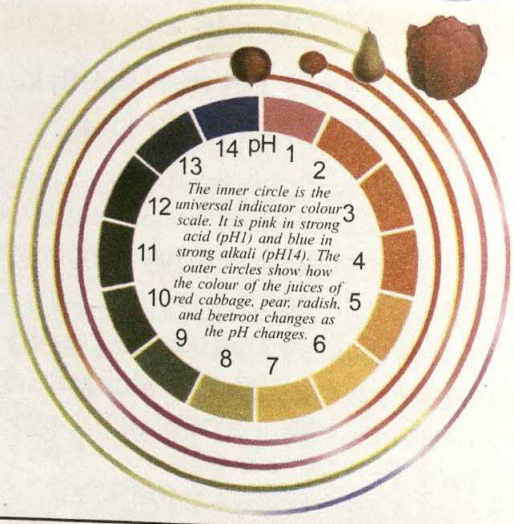
The liquid which you obtained by boiling the red cabbage is an indicator, a substance which has a special ability to take on a different colour according to whether it comes into contact with an acid (when it becomes red) or an alkali (becoming green or blue). In this experiment, the liquid indicator has shown you that lemon juice is an acid substance, bicarbonate of soda is an alkali substance, and the water is neither acid nor base, but neutral, shown by the way it keeps its colour.

INDICATORS

There are many different indicators that can tell us the acidity or alkalinity of a solution. A very useful indicator is a mixture of dyes known as universal indicator. This gives a range of colour changes from red for pH 1 (very strong acid) to blue for pH 14 (very strong alkali). The dyes obtained from fruits and vegetables, such as pears, onions, and red cabbage, can also be used as indicators. They change colour as the pH changes. The juice of a red cabbage, for example, turns from red in strong acid, through to pink, purple, blue, and green in strong alkali.

Different indicators are used in chemical laboratories. Among these are litmus papers–strips of paper soaked in a special substance which changes colour when it comes into contact with an acid or an alkali–and methyl orange, which reveals the presence of an alkali by going red.





CHEMISTRY AROUND US

HOW DOES YEAST MAKE THE DOUGH RISE ?

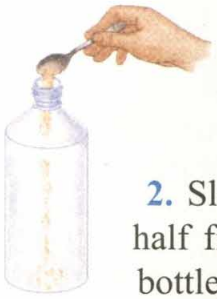
As yeast converts the sugar contained in flour, it gives off a gas, carbon dioxide, which makes dough rise.

TRY IT YOURSELF

Things you will need

★ A plastic bottle ★ About 150ml of warm water ★ Yeast ★ Sugar ★ A teaspoon ★ A balloon

Directions



1. Put three teaspoons of yeast into the bottle. Add two teaspoons of sugar.

2. Slowly half fill the bottle with warm water.

3. Place the balloon on the neck of the bottle. Wait for about an hour.

Result

The liquid becomes frothy and the balloon inflates.

Reason

The yeast is a microscopic fungus which feeds on the natural sugar contained in flour. As this happens, a gas–carbon dioxide is produced. This gas forms lots of bubbles which rise up towards the surface (that is why the liquid becomes frothy) and expands into the air above, inflating the balloon.

MAKING BREAD

One of the ingredients of bread is yeast. After the dough has been kneaded, it is put in a warm place. The yeast rest respires with oxygen by feeding on the sugars and breaking them down into carbon dioxide and water. These gases cause the dough to rise. As you bake the dough, the yeast is killed, and the gases expand to give the bread a spongy texture. If dough without yeast is used, it will not rise, The bread it makes is called unleavened bread.

CHEMICAL SUBSTANCES IN FOOD

The food which we eat are generally formed of natural chemical substances, which we get from plants and animals. The substances which we must eat to maintain a healthy body can be subdivided into three categories :

1. Carbohydrates (found in bread, sugar, pasta, fruit and vegetables) which give us immediate energy, because they are burned up quickly by our bodies.

2. Fats (such as cooking oil, butter and margarine) which also give us energy, but more at a slower rate.

3. Proteins (found in meat, fish, eggs and cheese) and which constitute the materials needed for growth, healthy bones and the maintenance of the body.

Foods also provide us with other vital substances—vitamins, mineral salts and a part of the water which we need everyday.

CHEMISTRY AROUND US

HOW DOES THE STOMACH BREAK UP FOOD ?

Our bodies produce enzymes which transform foods into substances which are easier to digest.

TRY IT YOURSELF

Things you will need

★ Two glass jars ★ Two hard-boiled eggs (shelled) ★ Ordinary detergent ★ Biological detergent with enzymes ★ Warm water ★ A spoon ★ A pen ★ Two labels.

Directions

1. Put a spoonful of normal detergent in one jar. Put a spoonful of biological detergent with enzymes in the other jar.

2. Label the jars to show which is which.

3. Pour water in both jars. Mix thoroughly until the detergent is dissolved.

4. Put a hard-boiled egg in each jar. Place the jars in a warm place, but not in direct contact with a source of heat. Leave for a few days.

Result

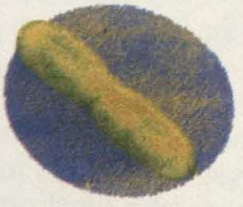
In the jar with the normal detergent, the egg has not changed. In the jar with the biological detergent, the egg looks as if it has been partly eaten.

Reason

The biological detergent contains enzymes. An enzyme is a special chemical substance which either makes a chemical reaction possible or speeds up a chemical reaction. The enzymes in the biological detergent 'eat' at the egg in the same way as they do with a speck of dirt, by separating the molecules and making them soluble in water. Our body also produces enzymes to break up food into very small particles which the digestive system can use more easily.

DIGESTION

Digestion begins in the mouth, as teeth crush the food. Watery saliva moistens the food and makes it easy to chew and swallow. The muscular walls of the stomach churn the food into a soup-like liquid and mix it with powerful digestive juices. The broken-down nutrients are small enough to seep through the lining of the small intestine and into the blood vessels in its wall.



Enzymes

Digestive juices contain proteins called enzymes which dissolve the food into tiny particles the body can absorb.

Stomach

This J-shaped bag is lined with a thick layer of slimy mucus. Tiny glands in the lining produce strong digestive juices, which contain substances such as enzymes and acids.

Things you will need

* Iodine solution (as made for the experiment to detect starch)
* White flour
* Cold water, lukewarm water and hot water
* A spoon
* A teaspoon
* A cup
* A test tube
* A glass jar
* An eye-dropper
* A plate

Directions

1. In the cup, mix a spoonful of flour with a little cold water. Then fill the cup with hot water.

2. Leave the mixture to cool. Then spoon a little on to a plate. Add one or two drops of the iodine solution.

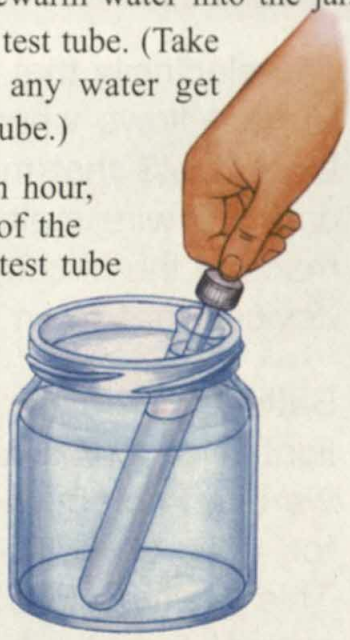
Result

The water and flour mixture has turned blue, revealing the presence of starch.

3. Put as much saliva as you can into a test tube. Add a spoonful of the water and flour mixture. Shake vigorously, keeping the test tube closed with your thumb.

4. Pour the lukewarm water into the jar. Then put in the test tube. (Take care not to let any water get inside the test tube.)

5. Every half an hour, remove a little of the contents of the test tube with eye dropper and repeat the test with the iodine solution. Do not forget to wash the plate each time.



Result

Little by little, as time passes, the iodine solution causes a change of colour in the flour mixture. Changes are always slightly evident, until the colour has changed completely.

Reason

The saliva contains an enzyme (amylase) which is able to transform the starch into malt, a sugar which is more easily digested by the body. Try to chew a little piece of bread very slowly. At first, it tastes salty, then sweet. That change happens because of the action of the amylase.

ELECTRICITY

Electricity heats and lights our homes. It is the kind of ENERGY, that powers electric trains, vacuum cleaners, radios, television, computers and many more devices.

The electricity that we use flows through wires as electric current. Current flows when tiny particles called electrons jump between the ATOMS that make up the metal in the wire. Current can flow only if a wire makes a complete loop called a circuit. If a gap is made in the circuit, the current stops flowing. Switches are simply devices that open and close gaps in circuits.

Batteries produce electric current that can be used to start cars, light torch bulbs and work radios etc. But most of the electricity we use is produced in power stations. In a power station generator, coils of wire are made to rotate between powerful magnets. This makes electric current flow through the coils of wire. This current then flows through other long wires to our homes.

ELECTRONICS

Electronics is an important part of the study of ELECTRICITY. It deals with the way in which tiny particles called electrons flow through certain CRYSTALS, gases or a VACUUM. Electronic devices like TRANSISTORS and SILICON CHIPS are used in such things as Computers, Reader, Television and Radios. Electronics helps us to see the smallest living thing, to guide planes and to do difficult calculations instantly.

You will find the answers about *"Static Electricity, The Electric Current, Circuits and Switches, The Effects of Electric Current and many more"* by doing the experiments in this section.

HOW CAN SOMETHING BE ELECTRIFIED ?

A thing becomes electrified because the amount of electrons in its atoms is either increased or diminished.

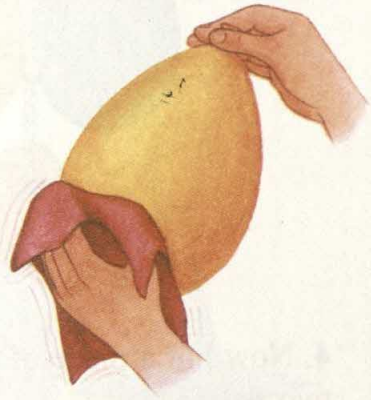
TRY IT YOURSELF

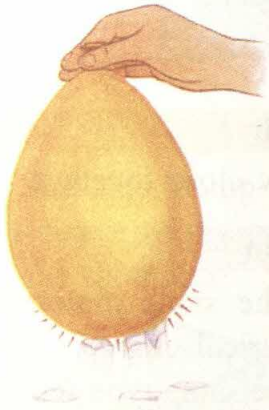
Things you will need

- A balloon
- Some pieces of thin paper
- A wall
- A tap
- A piece of woollen material

Directions

1. Blow up the balloon. Stroke it vigorously with the piece of material.





2. Hold the balloon close to the pieces of paper, without touching them.

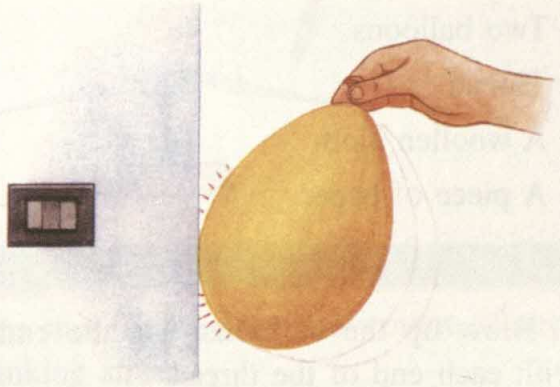
Result

The pieces of paper jump up and stick to the balloon.

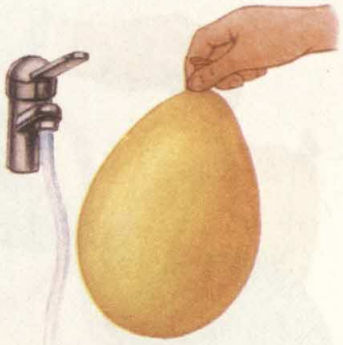
3. Stroke the balloon again with the cloth. Hold the balloon close to the wall.

Result

The balloon sticks to the wall.



4. Turn on the tap. Stroke the balloon again and hold it near the stream of water.



Result

The jet of water curves and follows the movement of the balloon.

Reason

When you stroke the balloon with the woollen material, it became electrified, with the power to attract things, almost like a magnet. You can also try holding the balloon near your hair, and see how the hairs rise up, as if by magic.

WHY DO SOME ELECTRIFIED OBJECTS ATTRACT AND OTHERS REPEL ?

Electrical charges can be positive or negative. Charges of the same type repel. Opposite charges attract.

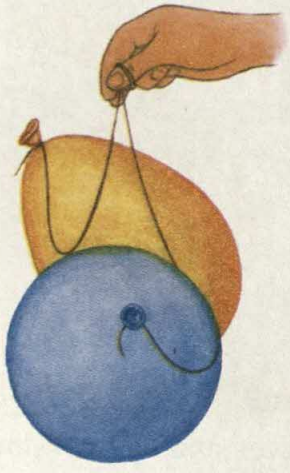
TRY IT YOURSELF

Things you will need

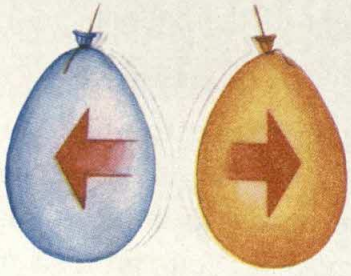
- ★ Two balloons
- ★ Thread
- ★ A woollen cloth
- ★ A piece of paper

Directions

1. Blow up the balloons. Tie the ends with each end of the thread.



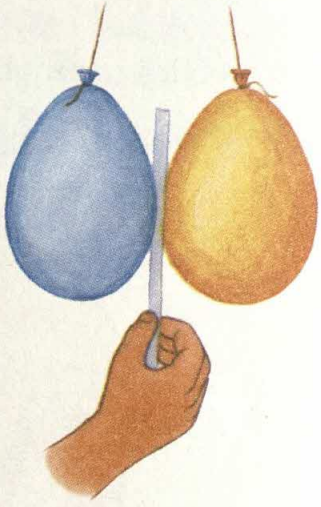
2. Stroke both balloons with a woollen cloth.



3. Lift the thread at the centre, and let the balloons hang down towards the floor.

Result

The two balloons draw away from each other.



4. Now put a piece of paper between the two balloons.

Result

The two balloons draw close together.

Reason

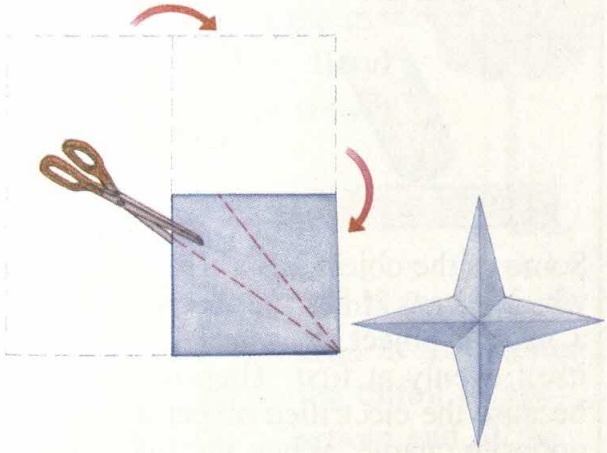
Because objects of the same material acquire the same electrical charge. And electrical charges of the same type repel. The balloons, which both have a negative charge, draw away. The paper, which is not electrified, has the same number of negative and positive charges. It is the positive charges which attract the negative charges of the balloon.

Things you will need

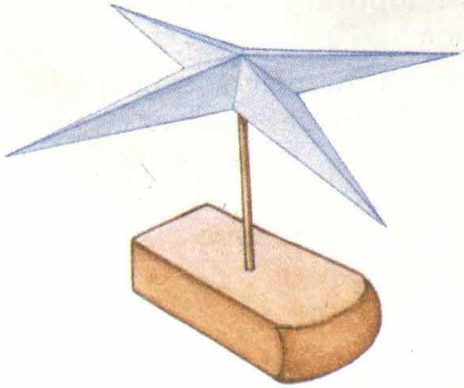
- A drinking straw
- A square piece of thin paper
- A toothpick
- A woollen cloth
- An eraser
- Scissors

Directions

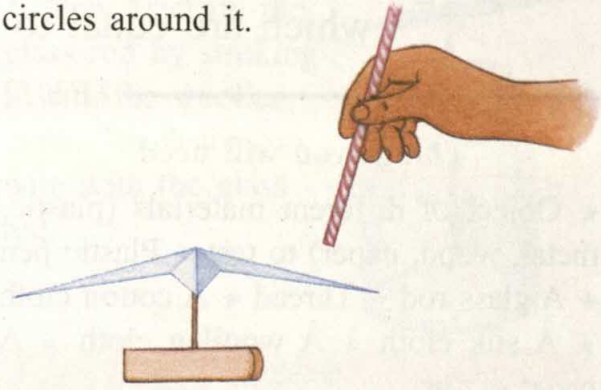
1. Fold the piece of paper into four, and cut as shown in the picture. When you unfold the paper, you will have a star shape.



2. Stick the toothpick in the eraser. Place the centre of the paper star on the point of the toothpick.

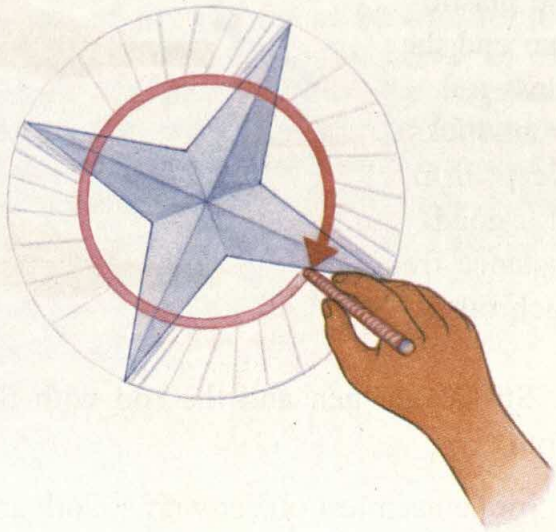


3. Stroke the drinking straw with the woollen cloth. Then move the straw around the top of the star, as if drawing circles around it.



Result

The star follows the movement of the drinking straw.



Reason

Because stroking with the woollen cloth has given the straw a negative electrical charge. So the straw can attract the opposite (positive) charge of the paper. That is why the star follows the movement of the straw.

STATIC ELECTRICITY

HOW IS THE TYPE OF ELECTRICAL CHARGE REVEALED IN AN OBJECT ?

The charge which are equal to that of the glass are positive. Those which are equal to the plastic are negative.

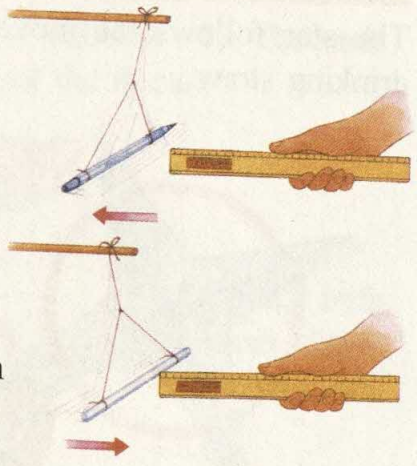
TRY IT YOURSELF

Things you will need

★ Object of different materials (plastic, metal, wood, paper) to test ★ Plastic pen ★ A glass rod ★ Thread ★ A cotton cloth ★ A silk cloth ★ A woollen cloth ★ A piece of fur

Directions

1. Using the thread, hang the plastic pen and the glass rod from sticks. Keep them at a good distance from each other.



2. Stroke the pen and the rod with the cloth.

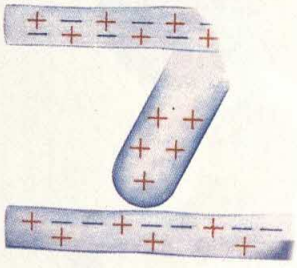
3. Stroke each test object with a cloth and bring each one near to the pen in turn. Then hold each object near to the glass rod.

Result

Each object is electrified by stroking with the cloth. This causes the object to repel from one of the charged objects (the pen or the rod) and to attract the other.

Reason

The plastic pen has a negative charge. The glass rod has a positive charge. From this, we know that the objects which attract the plastic pen and repel the glass rod have a positive charge. Those which cause the opposite effect have a negative charge.



INDUCTION AND CONTACT

Some of the object has a neutral charge, which means it has no charge at all. In a neutral object the charge distributes itself evenly at first. Then it separates, because the electrified object attracts an opposite charge. When the two objects are separated, the charge of the neutral object once again distributes itself evenly. The neutral object immediately has a temporary electrification by induction.

If we touch the neutral object with an electrified object with, let us say, a positive charge, it will attract neutral object and neutralize its negative charge. So the positive charge would then be present in both objects. But, such electrification by contact does not last.

Things you will need

★ A glass jar ★ A cork which fits tightly enough to act as a seal ★ A length of iron wire ★ A strip of tinfoil ★ A glass rod and a plastic rod ★ A woollen cloth

Once the experiment has been set up, take care not to touch the iron wire with your hand, otherwise the electrical charge will be lost.

Directions

1. Thread the wire through the centre of the cork, so that it sticks out at the top and at the bottom. Bend the bottom end, as shown in the picture.

2. Fold the strip of tinfoil in half. Hang the tinfoil on the bottom end of the wire. Place the cork on the top of the jar.

3. Stroke the plastic rod with the woollen cloth. Then touch the top end of the wire with the plastic rod.

Result

The two 'fins' of the tinfoil spread apart.

4. Now electrify the glass rod by stroking it with the woollen cloth. Touch the top wire with the glass rod.

Result

The tinfoil 'fins' close together.

Reason

Because the contact between the plastic rod and the wire causes the negative charge of the plastic to be transmitted through the wire to the two halves of the tinfoil. As these acquire the negative charge, they repel. When you bring the glass rod closer, the positive charge of the rod neutralizes the negative charge and the two halves close again. The same thing happens by touching the wire first with the glass rod and then bringing the plastic rod near (both are electrified).

The instrument you have made is an *electroscope,* used to detect a positive or negative charge. You can repeat the experiment, charging your electroscope each time with a negative charge (by contact with the plastic) or a positive charge (by contact with the glass). Then test objects of different materials which have been electrified by stroking. When the tinfoil fins close together, the object is something with a positive charge. When they open, it is something with a negative charge.

STATIC ELECTRICITY

WHAT IS LIGHTNING ?

Lightning is an electrical charge from a highly electrified cloud to the Earth.

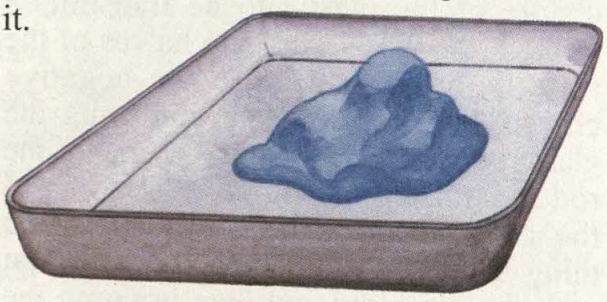
TRY IT YOURSELF

Things you will need

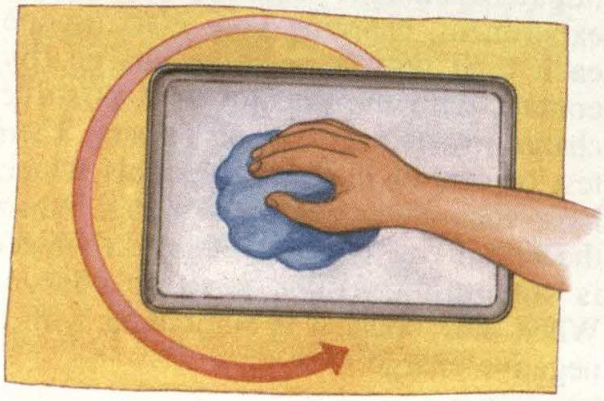
- ★ A large, flat baking dish
- ★ A large handful of plasticine
- ★ A sheet of plastic
- ★ A coin
- ★ A dark room

Directions

1. Soften the plasticine and stick it down in the centre of the dish. The plasticine must be stuck down firmly enough for you to be able to lift the baking dish with it.



2. Place the baking dish on the sheet of plastic. Then, using the plasticine, stroke the dish vigorously around the plastic for about a minute.

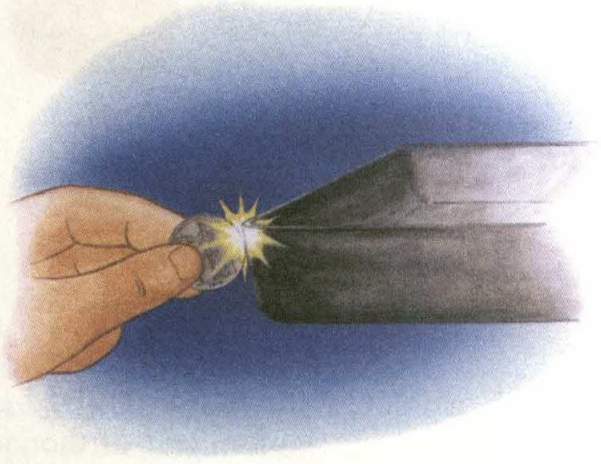


3. Still using the plasticine, lift up the baking dish. Take care not to touch the baking dish with your hands.

4. In the dark room, bring a coin close to the corner of the dish.

Result

The contact between the coin and the dish produces a spark.



Reason

Because having been stroked on the plastic, the baking dish is electrified with a negative charge. When you brought the coin closer, the excess charges were quickly transferred through the air, from the sheet to the coin, and to your body (you will have felt a slight shock). The passage in the air was shown by the spark. This experiment reproduces in miniature a flash of lightning in a storm.

THE ELECTRIC CURRENT

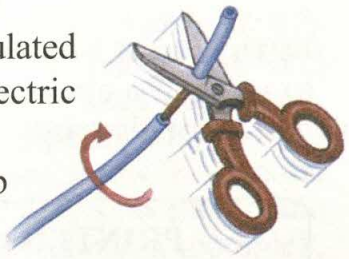
HOW IS AN ELECTRIC CURRENT GENERATED ?

When electrical charges move in a circuit between two objects, these objects will have a certain difference in potential.

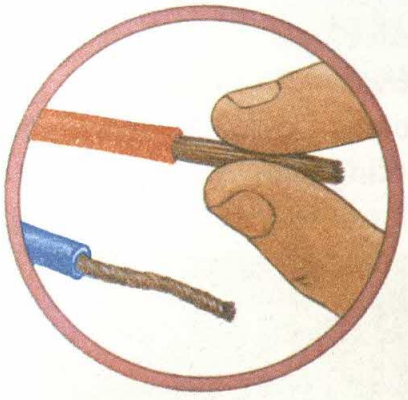
TRY IT YOURSELF

Things you will need

- ★ A 4.5 volt battery
- ★ Two pieces of insulated (plastic covered) electric cable
- ★ A small light bulb
- ★ Wire-cutters

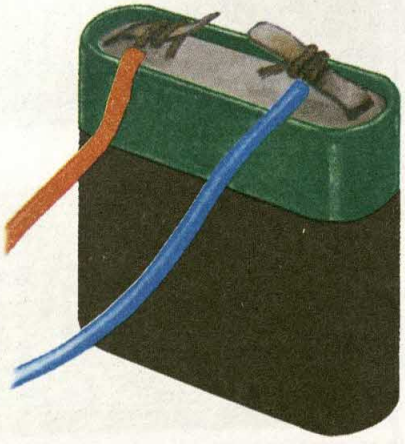


Directions

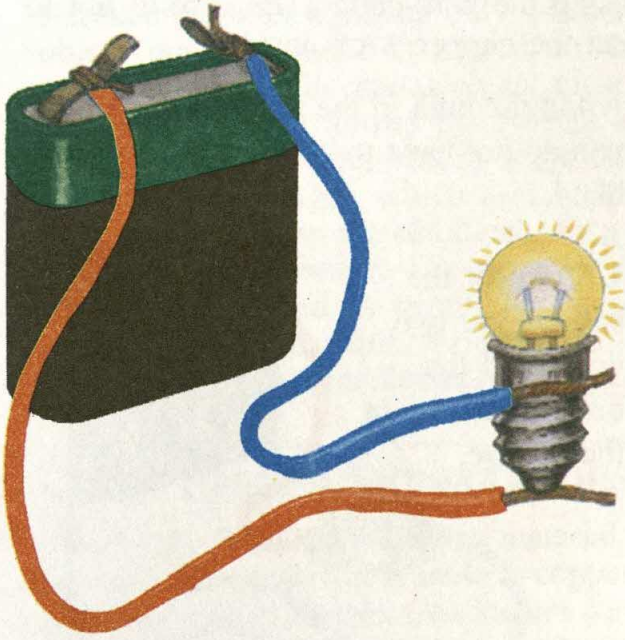


1. Use the wire-cutters to peel off the plastic from both ends of the wires. (Ask an adult to do this for you). Be careful not to cut the copper wires inside.

2. Wind the uncovered end of each piece of wire around a battery contact, as shown.



3. Take the two free ends of wire and place them on the bulb. One wire must touch the bottom of the metal screw and the other against the side.



Result

The bulb lights up.

Reason

Because what you saw transformed into the light energy of the bulb was the electrical current. This is a flow of electrical charge conducted from the battery through the wires and into the bulb, along a set course called a circuit.

ELECTRICITY

THE ELECTRIC CURRENT

Things you will need

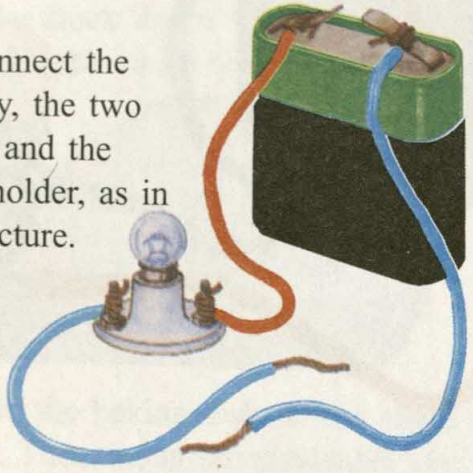
- ★ A 4.5 volt battery
- ★ Three pieces of insulated electric cable
- ★ A small bulb
- ★ Wire-cutters
- ★ A bulb-holder

Directions

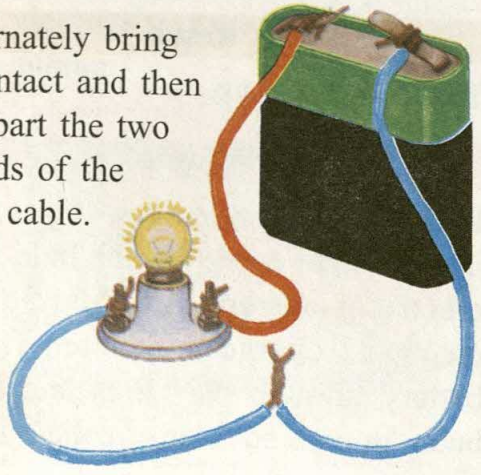
1. Ask an adult to peel away the plastic from the ends of the pieces of wire, using the wire-cutters.(Be careful not to cut the copper wires inside!)

2. Put the bulb in the bulb-holder, so that you do not have to hold the bulb in your hand.

3. Connect the battery, the two wires and the bulb-holder, as in the picture.



4. Alternately bring into contact and then draw apart the two free ends of the electric cable.



Result

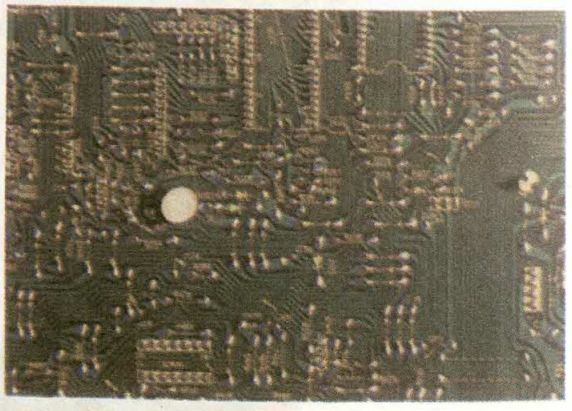
When the wires touch, the bulb lights up. When they are apart, it remains unlit.

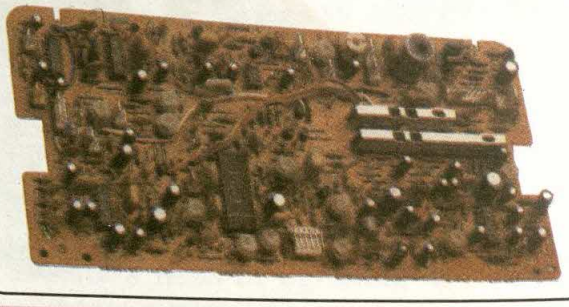
Reason

Because the circuit (the course through which the electricity flows from the battery) must be unbroken (closed) for it to work. If a circuit is broken (open), the current of electricity cannot flow through it.

PRINTED CIRCUITS

Machines like computers and television sets contain many electrical parts. Instead of travelling through wires, current electricity flows along lines printed on boards inside the machine. It goes to working parts of the machine mounted on these boards.





THE ELECTRIC CURRENT

CAN ELECTRICITY FLOW THROUGH ALL SUBSTANCES ?

Some materials are conductors of electricity. These allow the passage of current. Others are insulators. These stop the flow.

TRY IT YOURSELF

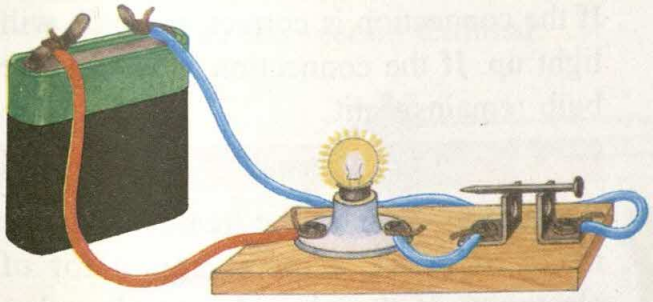
Things you will need

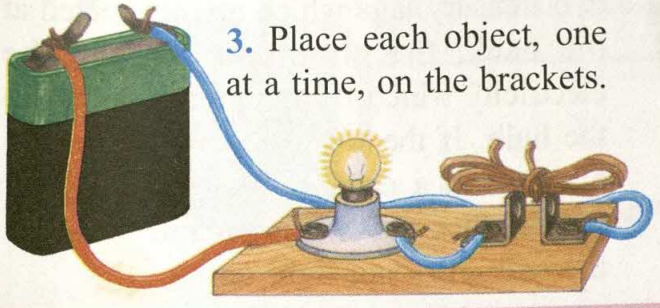
★ A 4.5 volt battery ★ A 5 volt bulb in a bulb-holder ★ Three pieces of insulated electric cable (with the ends uncovered, as in the last two experiments) ★ Two metal brackets ★ Two screw ★ A tablet of wood ★ Some objects to put to the test: a nail, a strip of rubber, a toothpick, a strip of tinfoil, a glass rod, a leather shoe-lace, a drinking straw

Directions

1. Screw the two brackets to the wood, about 2cm apart.

2. Place the bulb alongside the brackets and connect the battery, the bulb-holder and the two brackets with the three pieces of electric cable, as shown in the picture.





3. Place each object, one at a time, on the brackets.

Result

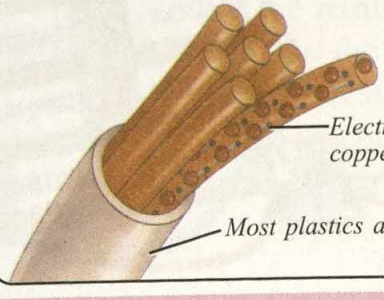
The nail and the tinfoil make the bulb light up. The other objects do not.

Reason

Because the bulb lights up only when an object made of metal is placed on the metal brackets. The metal object closes the circuit and so allows the current to flow. Rubber, plastic, wood, glass and leather are insulators, which means that these materials trap the electrical charge, and do not let it escape. These insulating materials are used as protection from electricity. Electric cable, for example, is the outside without the handler getting an electric shock.

CONDUCTORS AND INSULATORS

Electricity flows only through materials called conductors. These include copper and many other metals. Conductors can carry electricity because their electrons are free to move. Other substances, called insulators, do not allow electricity to flow through them. This is because their electrons are held tightly inside their atoms.



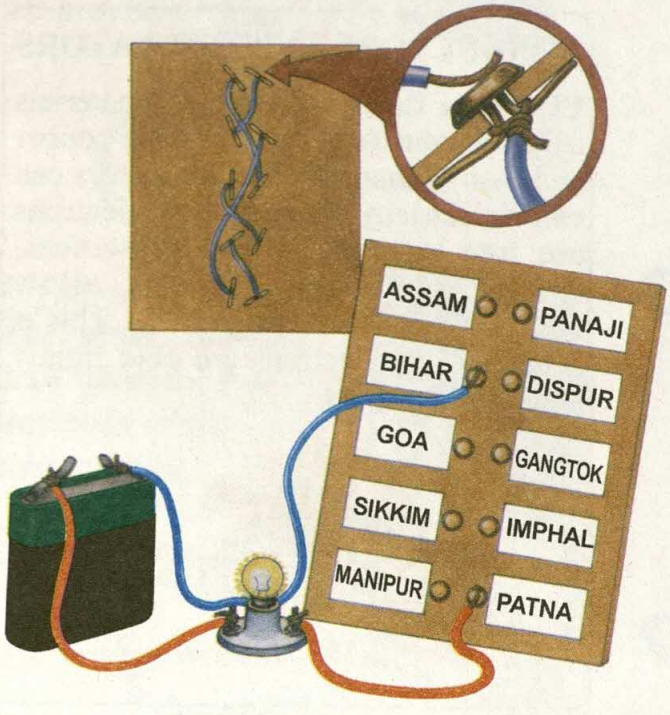
THE ELECTRIC CURRENT

Things you will need

- A piece of strong cardboard
- A sheet of paper
- Ten treasury tags
- Electric cable
- Wire-cutters
- A 4.5 volt battery
- A small bulb with bulb-holder
- Glue
- A pencil
- Scissors

Directions

1. Cut 10 rectangles from the paper. On these write the names of states and their 5 capital cities. Then paste them on the cardboard, so that the states and the capital cities are mixed up.



2. Make 10 holes in the cardboard against each name. Thread a treasury tag through each hole.

3. Ask an adult to cut 5 pieces of electric cable and strip the plastic off with wire-cutters. On the back of the cardboard, use the wire to connect each state with its correct capital city. (Wind the wire around the metal 'fins' of each treasury tag.)

4. With another piece of electric cable, connect a battery contact with one side of the bulb-holder. Take another two piece of wire. Connect one to the other battery contact and the second to the free side of the bulb-holder. The other two ends of these wires will be left free.

5. Invite a friend to try matching up the right state with the right capital city, using the free ends of the wires.

Result

If the connection is correct, the bulb will light up. If the connection is wrong, the bulb remains unlit.

Reason

Because the ends of the treasury tags are made of brass, a metal conductor of electricity. If the player's wires touches two treasury tags which are connected at the back, the circuit closes and the electricity which flows through, lights up the bulb. If the wires are placed next to a state and a capital city which are not correct, then the circuit remains open and the bulb does not light up.

THE ELECTRIC CURRENT

CAN WATER CONDUCT ELECTRICITY ?

Pure water is an insulator, but water containing salt is a good conductor of electricity.

TRY IT YOURSELF

Things you will need

- ★ A glass or plastic container
- ★ Two small terminals (clamps)
- ★ Electric cable
- ★ A 4.5 volt battery
- ★ A bulb
- ★ Distilled water (from a garage of hardware shop)
- ★ Salt
- ★ Wire-cutters

Directions

1. Fill the container with distilled water.

2. Ask an adult to cut 3 pieces of cable. Strip the ends. Connect one end of 2 wires to the battery contacts, and one free end to a terminal. Connect one end of the third wire to the second terminal.

3. Place a terminal on each side of the container, so that these touch the water.

4. Connect the free ends of the wire to the bulb, one wire touching the bottom of the metal screw, the other touching the side of the screw.

Result

The bulb does not light up.

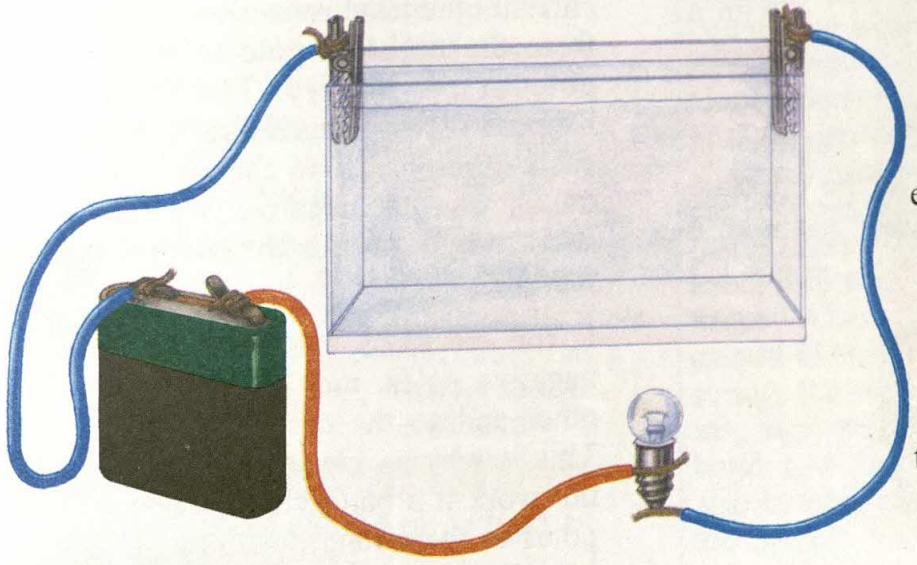
5. Add a few handfuls of salt to the water. Reconnect the wires to the bulb.

Result

The bulb lights up.

Reason

Because the distilled water is an insulator which means that it prevents the flow of the electrical charge. But if you add salt to the water, it becomes a conductor. When the salt dissolves, the particles in it, being electrically-charged, start to become attracted to the terminals connected to the battery. This creates a sort of connection which closes the circuit and so allows the electricity to pass through.



THE ELECTRIC CURRENT

WHY IS THE POSITION OF THE BATTERY IMPORTANT ?

The flow of current generated by batteries can happen only between poles of the opposite sign.

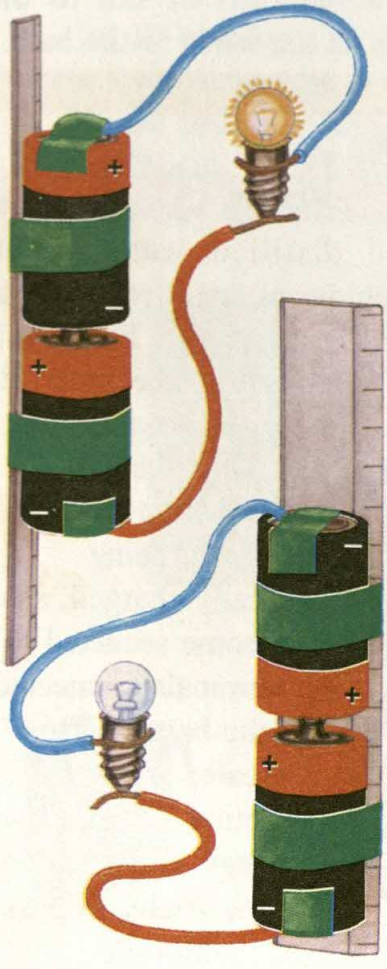
TRY IT YOURSELF

Things you will need

- ★ Two 1.5 volt batteries
- ★ A small bulb
- ★ Two pieces of electric cable with the ends uncovered
- ★ A ruler
- ★ Sticky tape

Directions

1. Stick the two batteries along the length of the ruler with the sticky tape. Follow a positive pole (marked with a plus [+] sign) with a negative pole (marked at the opposite end with a minus [–] sign).



2. Use the sticky tape to stick the ends of the two wires to the opposite heads of the batteries. Bring the two batteries together. Then touch the bulb with the free ends of the wires, as shown.

Result

The bulb lights up.

3. Now reverse the position of the batteries, so that the two positive poles touch.

4. Re-connect the wires to the two ends of the 'double' battery.Touch the bulb again.

Result

The bulb does not light up.

Reason

Because when they generate an electrical current, the electrons flow continually from the negative pole to the positive pole of the battery. The same thing happens if two batteries are connected to each other, because the electrons still escape from the negative pole on the one hand and go towards the positive pole on the other.

If the electrons escape from both the negative poles, they go one against the other and so the current does not flow. This is why an electric torch or toy will not work if a battery is inserted with the poles in the wrong positions.

CIRCUITS AND SWITCHES

CAN A CIRCUIT LIGHT UP MORE THAN ONE BULB ?

One circuit can power more than one bulb continuously, whether connected in series or in parallel.

TRY IT YOURSELF

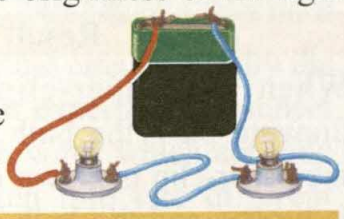
Things you will need

★ Two 4.5 volt batteries ★ 4 bulbs, each with a bulb-holder ★ Electric cable ★ Wire-cutters (remember that each time you cut a piece of wire, you must strip the plastic off both ends; ask an adult to do this)

Directions

1. Connect one bulb to one of the batteries. Note the brightness of the light which it gives.

2. Connect two bulbs to the same battery, as shown in the picture.

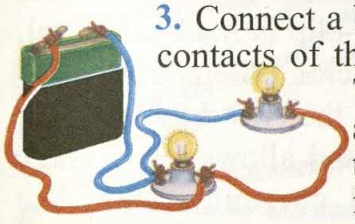


Result

The two bulbs give out a light which is not so bright.

Reason

Because the two bulbs 'share' the same energy, which passed first from one and then to the other. What you have built is called a series circuit. If you touch one of the two bulbs, the circuit will be broken and the other bulb will go out.



3. Connect a bulb-holder to the contacts of the second battery. Then connect another bulb to the first, as shown in the picture.

Result

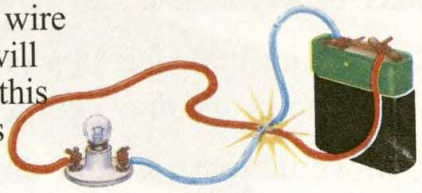
The two bulbs give out the same light as the bulb on its own.

Reason

Because each bulb is on a precise circuit which is fed directly from the battery. This type of circuit is called a parallel circuit. If one of the bulbs burns out or becomes detached, the other continues to shine because its own circuit is not broken.

A SHORT CIRCUIT

If it is not kept under control, an electrical current can cause damage and lead to danger. One of the most common faults is the short circuit. If you were to take a short length of the insulating plastic coating off each of the wires which connect the battery to the bulb and put these in contact with each other, you would see them giving off sparks, and the bulb would go out. In this way, the current does not complete all the circuit, but returns directly to the battery without passing through the bulb, completing a circuit which is shorter. Not meeting any resistance on this circuit, the current becomes more intense (stronger) and so produces a lot of heat. In electrical installations, a short circuit can cause fires or seriously damage the installation. To avoid this as you will soon see, we use **safety valves** called **fuses**. When there is an **overload** of current in the circuit, or the current is too strong, the wire in a fuse will break and this also breaks the circuit.



CIRCUITS AND SWITCHES

WHY DO WE NEED SWITCHES ?

A switch either closes or opens an electrical circuit, as needed.

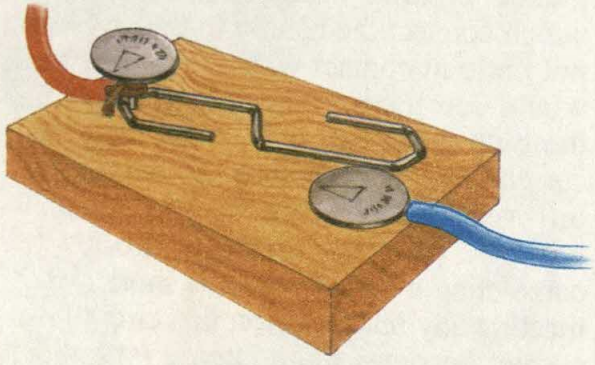
TRY IT YOURSELF

Things you will need

- ★ A tablet of wood
- ★ Two small drawing pins
- ★ A metal paper-clip
- ★ Three pieces of insulated electric cable with the plastic stripped off the ends (ask an adult to do this)
- ★ A bulb with a bulb-holder
- ★ A 4.5 volt battery

Directions

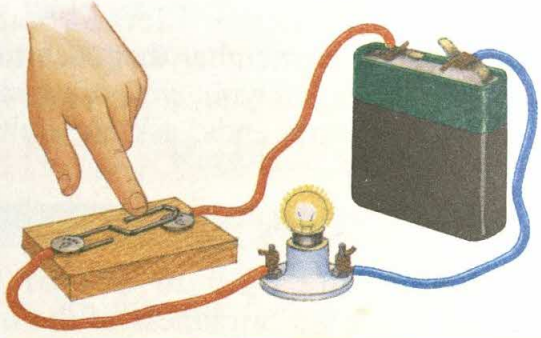
1. Stick the two drawing pins in the wooden tablet, about 3-4cm apart from each other.



2. Place the wire under each drawing pin. Connect the free end of one wire to a battery contact and the free end of the other wire to the bulb-holder. Connect the third wire from the bulb-holder to the other battery contact, as shown.

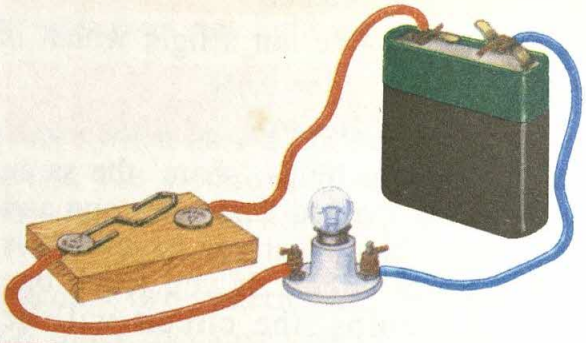
3. Open up the paper-clip and thread it under one of the drawing pins.

4. Move the other end of the paper-clip and bring it into contact with the second drawing pin. Then push the end of the paper-clip away.



Result

When the paper-clip touches both drawing pins, the bulb lights up. When the paper-clip is drawn away, the contact is broken and the bulb remains unlit.



Reason

Because the paper-clip is made of metal, which is a conductor of electricity. So when this touches the two drawing pins, the circuit closes and allows the passage of the electrical current. When the paper-clip is drawn away from the drawing pins, the circuit is open, and the passage of the current is interrupted.

CIRCUITS AND SWITCHES

Things you will need

- ★ Two tablets of wood
- ★ Two bulbs, each with a bulb-holder
- ★ Eight pieces of electric cable, with the plastic stripped off the ends. (Ask an adult to do this).
- ★ Four drawing pins
- ★ Two metal paper-clips
- ★ Two 4.5 volt batteries
- ★ Paper
- ★ A pen

Directions

1. Make two electrical circuits exactly the same as for the last experiment. Connect the two bulbs with wires which are long enough to be taken into two different rooms.

2. With a friend, work out a code along the same lines as the Morse Code, with each letter of the alphabet corresponding to a long or a short flash of light.

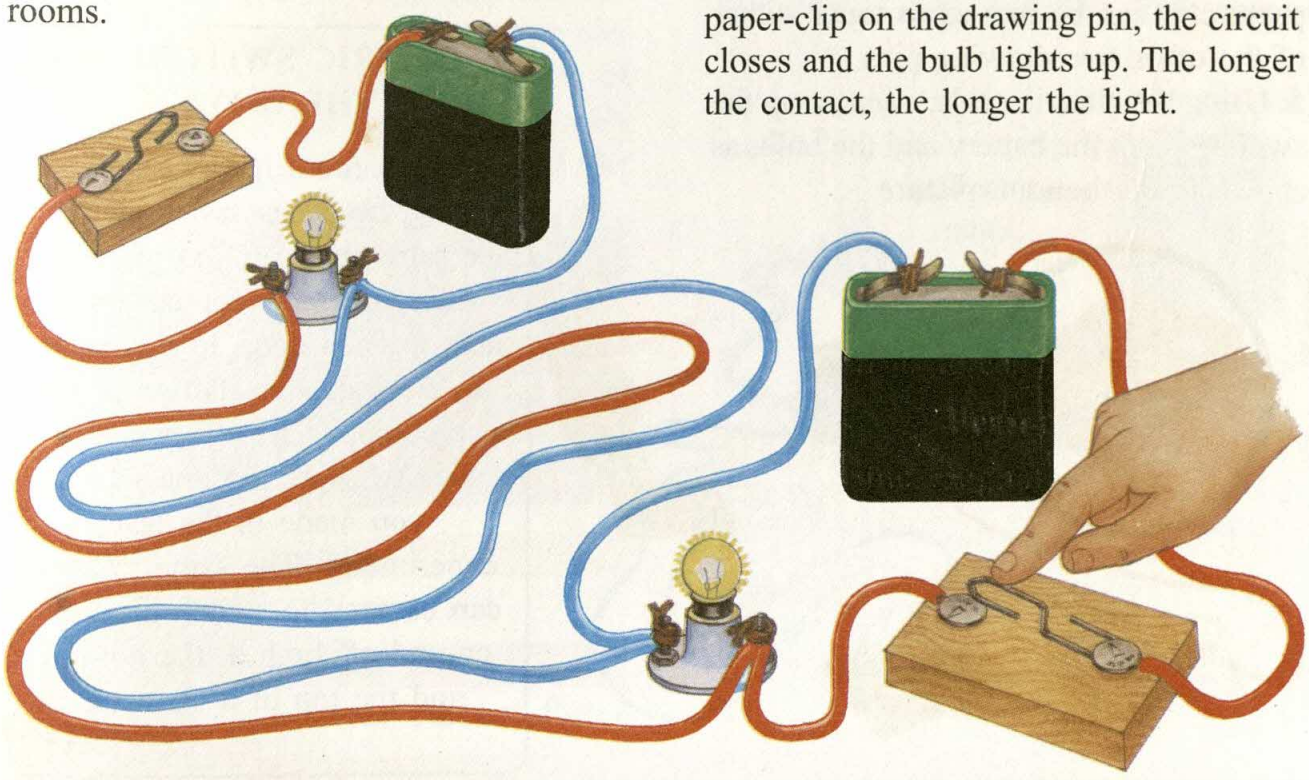
3. Send your friend a short message from one room to the other. When he or she has the switch 'open', then you can 'operate' yours. For each short flash, press the paper-clip on the drawing pin quickly. For each long flash, keep the paper-clip on the drawing pin a little longer.

Result

Your friend will receive your message in the form of light signals. You can then send an answer in the same way.

Reason

Because with each pressure of the paper-clip on the drawing pin, the circuit closes and the bulb lights up. The longer the contact, the longer the light.



CIRCUITS AND SWITCHES

WHAT IS A CURRENT GATE ?

A current gate allows an electrical circuit to open or close in one of two different directions.

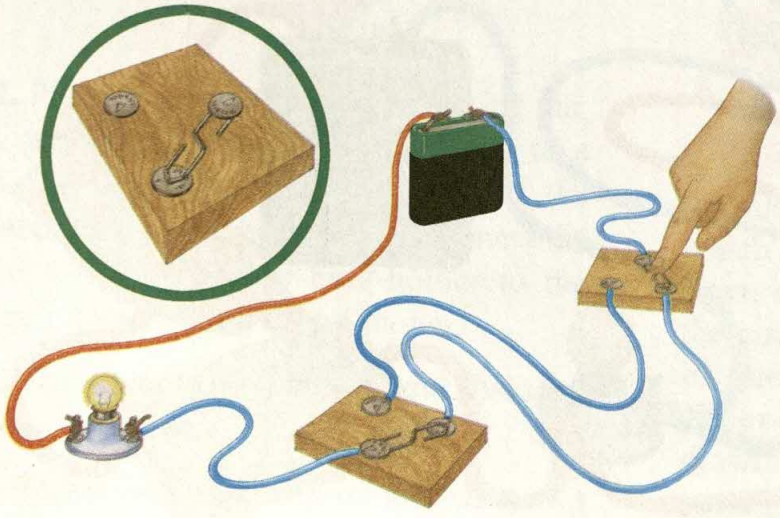
TRY IT YOURSELF

Things you will need

- ★ Electric cable
- ★ 6 drawing pins
- ★ Two paper-clips
- ★ A 4.5 volt battery
- ★ Two small tablets of wood
- ★ A bulb and a bulb-holder

Directions

1. Push three drawing pins into each tablet of wood, as you see in the picture.
2. On each wooden tablet, open up a paper-clip and place one end under the centre drawing pin. In this way, the paper-clip can be moved to touch either of the other two drawing pins.
3. Using the electric cable, connect up the switches with the battery and the bulb, as shown in the bottom, picture.



4. Try out different positions of the switches to light up or to extinguish the bulbs.

Result

The bulb can be lit or extinguished by either of the two switches.

Reason

Because when both switches and the wire form an unbroken circuit, the current passes through the circuit and the bulb lights up. Each time one of the two paper-clips is moved, this opens the circuit and makes the light go out.

ELECTRIC SWITCHES IN THE HOME

When a room has two doors, it may be necessary to switch the same light on and off from different points–for instance, near to each door. In this case, an electrical installation must be equipped with a two-way switches, like the one which you made in the last experiments. The same system can be used to switch the light on and off both at the bottom and the top of a staircase.

EFFECTS OF THE ELECTRICAL CURRENT

HOW DOES A BULB LIGHT UP ?

The filament inside a bulb offers some resistance to the passage of the current. So the filament heats up and gives off light.

TRY IT YOURSELF

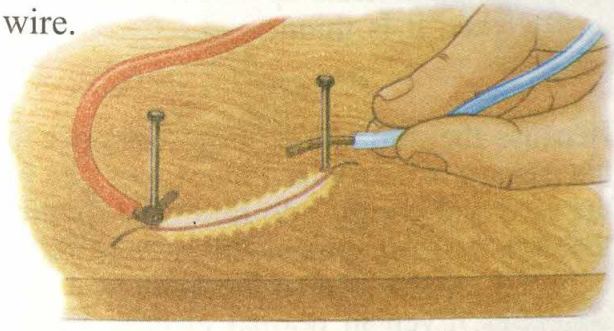
Things you will need

- A tablet of wood
- Two thin nails
- Steel filament (you can unravel this from a pan scourer)
- Two pieces of electric cable with the plastic stripped off the ends
- A 4.5 volt battery

Directions

1. Stick the two nails in the wood. Wind an end of the steel filament around the base of each nail.

2. Wind one end of a length of electric cable around a battery contact, and the other end around a nail, above the filament. Connect a second length of wiring to the other battery contact. Touch the other nail with the free end of the wire.



Result

The steel filament becomes red.

Reason

Because the electrical current flows easily through the electric cable. But it is more difficult for it to flow through the steel filament. That is why the flow of electricity heats up the filament and makes it change colour.

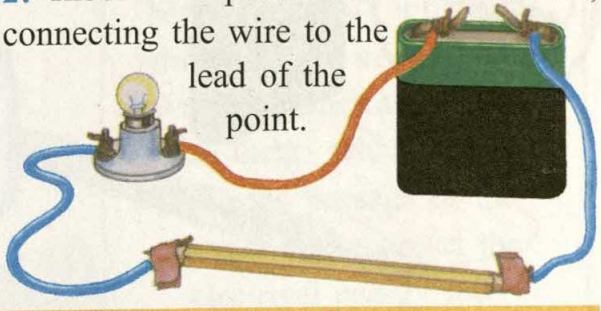
Things you will need

- One 4.5 volt battery
- One bulb, with bulb-holder
- Electric cable, with uncovered ends
- A new pencil with both ends sharpened to a point
- Sticky tape

Directions

1. Connect the bulb to the battery with the electric cable, as before. Take note of the light.

2. Insert the pencil into the circuit, connecting the wire to the lead of the point.



Result

The light from the bulb is not so bright.

Reason

Because the lead conducts the current, but offers some resistance of the flow. As it resists the flow, the lead absorbs part of the electricity and so the bulb dims.

EFFECTS OF THE ELECTRICAL CURRENT

DOES ELECTRICITY ALWAYS PRODUCE HEAT ?

Part of the electrical energy which goes through a conductor is always transformed into heat.

TRY IT YOURSELF

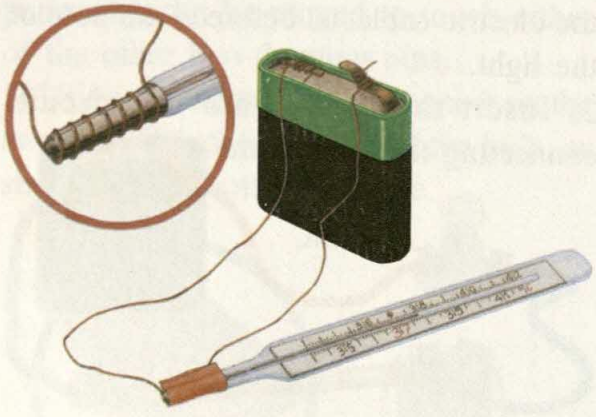
Things you will need

★ A mercury thermometer
★ A 4.5 volts battery
★ A length of thin copper wire
★ Insulating tape

Directions

1. Wind the copper wire around the bulb of the thermometer, so that the spirals do not touch and the end of the wire is fairly long. If necessary, you can fasten down the wire with the insulating tape.

2. Wind the ends of the wire around the battery contacts.



Result

After a few minutes, the temperature rises on the thermometer.

Reason

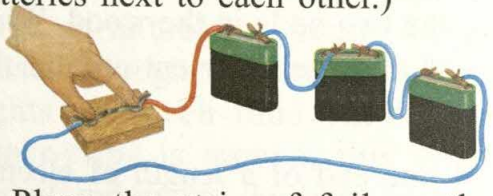
Because the electrical current which flows through the wire develops into heat.

Things you will need

★ Three 4.5 volt batteries ★ Electric cable, with the ends uncovered, as before
★ A tablet of wood with two drawing pins
★ A strip of aluminium foil

Directions

1. Connect the three batteries and the wooden tablet with the drawing pins as illustrated in the picture. (Take care not to have positive and negative poles of the batteries next to each other.)



2. Place the strip of foil on the two drawing pins.
3. Now cut the foil to make it thinner. Put the foil on the drawing pins once again.

Result

The aluminium heats up. It becomes even hotter when it is thinner.

Reason

Because the strip of foil offers resistance to the passage of current and transforms part of the electrical energy into heat. The thinner the strip, the more difficult the passage of the electrical current, and so the more heat this generates. Even in normal electric bulbs, brightness comes from the energy which flows through the filament into the bulb and becomes transformed into heat. That is why it is impossible to touch a bulb only moments after the power has been switched on.

WHAT DOES THE BRIGHTNESS OF LIGHT DEPEND ON ?

The brightness of a light depends on the speed with which the electrical charge flows through the conducting wires.

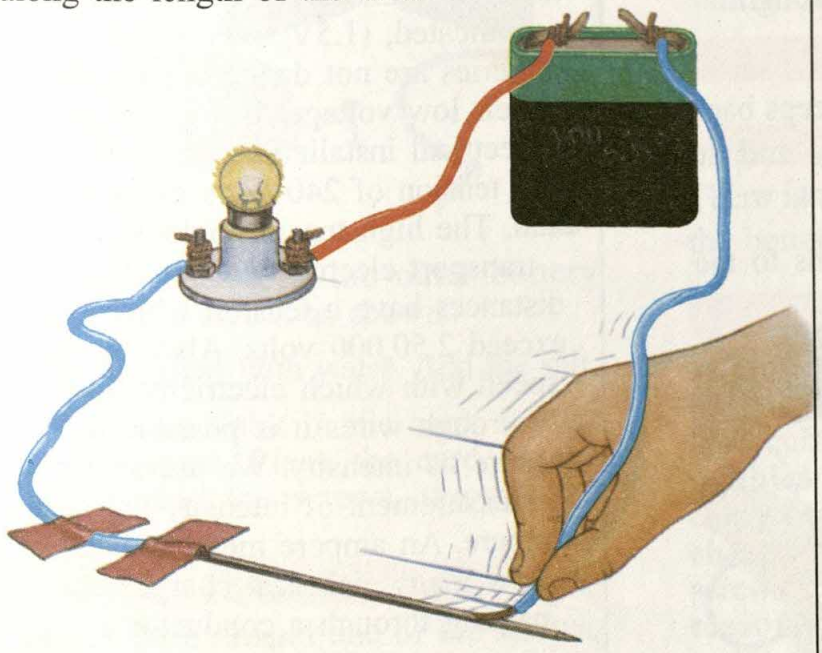
TRY IT YOURSELF

Things you will need

- A 4.5 volt battery
- A bulb with bulb-holder
- Electric cable
- A pencil lead
- Sticky tape

Directions

1. Connect the wire to the battery and to the bulb, as in the last experiment.
2. Open up the pencil. Take out the lead.
3. Fix the end of the wire to one end of the lead. Run the end of the other wire along the length of the lead.



Result

When the end of the wire is run along the length of the lead, the light in the bulb varies in brightness.

Reason

As we have already seen, lead offers resistance to the passage of the electrical current. The longer the length of the lead which is part of the circuit, the more the energy which is absorbed, and the less the brightness of the bulb.

USING THE HEATING EFFECTS OF ELECTRICITY

Many electrical appliances which we use in our homes have an electrical resistance inside them which heats up with the passage of the current and changes the electrical energy into thermal (heat) energy. This is what happens with things like electric cookers, toasters, electric irons, hair-dryers and electric blankets.

EFFECTS OF THE ELECTRICAL CURRENT

Things you will need

★ Three 4.5 volt batteries ★ A low-wattage light bulb with bulb-holder ★ Electric cable, with ends uncovered as before ★ Wooden tablet ★ Two drawing pins ★ A strip of tinfoil ★ A pencil sharpened at both ends

Directions

1. Connect the batteries together with the wiring. Make sure that the negative and positive poles are not next to each other.

2. Push the drawing pins into the wood. Connect these to the outer battery contacts and to the bulbs.

3. With the other two lengths of wiring, connect the two drawing pins to the points of the pencil.

Result

The bulb gives out a rather dim light.

Reason

Because the lead of the pencil keeps back some of the electrical energy and so resists the passage of the current.

4. Connect the two drawing pins to the strip of tinfoil.

Result

The bulb produces a dim light and then goes out.

Reason

The strip of tinfoil directly connects the bulb to the battery, as a parallel circuit. Therefore the bulb lights up with considerable brightness. However, the three batteries (each 4.7 volt) provides the low wattage bulb with a current which is too strong. Therefore the bulb filament fuses, interrupting the circuit.

VOLTS AND AMPERES

The electrical tension—that is the speed with which the electrical charge passes through a conductor—is measured in volts. On the batteries used in experiments and on those which power electrical items and toys, the number of volts is always indicated, (1.5V, 4.5V or 9V). Batteries are not dangerous because of their low voltage. But in the wires of electrical installations in the home, the tension of 240 volts can kill a man. The high tension pylons which transport electricity across long distances have a tension which can exceed 2,50,000 volts. Also, by the speed with which electricity flows through wires it is possible to measure its intensity. We use as a unit of measurement of intensity the term ampere. An ampere meter indicates how many electrical charges are passing through a conductor at a certain time.

EFFECTS OF THE ELECTRICAL CURRENT

WHAT CHANGES DOES ELECTRICITY CAUSE IN WATER?

When electricity passes through water it can break up and change the substances which the water contains.

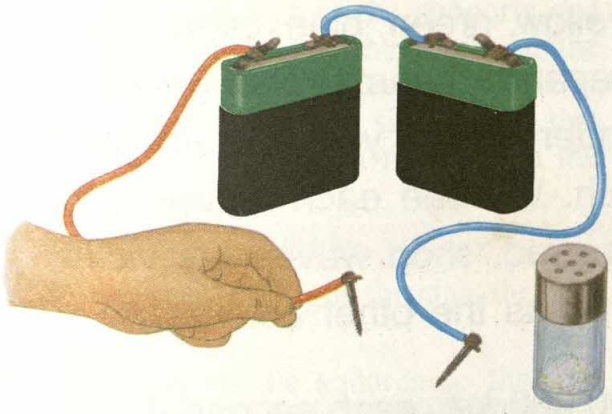
TRY IT YOURSELF

Things you will need

★ Electric cable (with ends stripped) ★ Two 4.5 volt batteries ★ Two large screws ★ A glass ★ Water ★ Salt ★ An old postcard

Directions

1. Connect the batteries with a piece of wire. (Negative and positive poles must not be together.)



2. Connect each of the outer battery contacts to a screw, as shown.

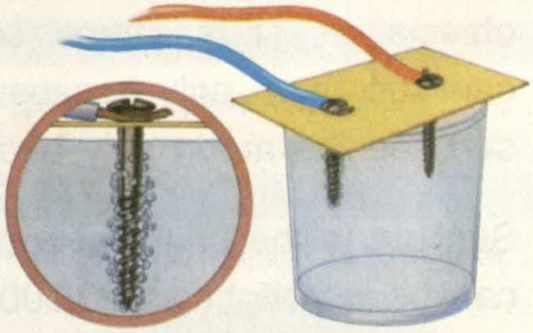
3. Fill the glass with water. Add the salt.

4. Make two holes in the card, a short distance apart. Place the card on the glass. Thread the screws, through the holes.

Result

Bubbles form around one of the screws.

5. Leave the screws in the water for a few minutes.



Result

The water around the screw with the bubbles becomes yellowish. Around the other screw the water is clear.

6. Take the screws out of the water.

Result

There is a deposit of green substance on the bottom of the glass.

Reason

Because chemical changes are caused by the passage of electrical current in water. The current breaks up the water (the bubbles are full of hydrogen, a component of water). The electricity also changes the salt and the iron from the screws into other substance. This is the reason for the discolouration of the water and the deposit on the bottom of the glass.

LIGHT

Light is a kind of ENERGY that we can see. Some objects.....stars, lamps, certain chemicals.....produce light. We can see them only because they reflect light. For example, we can see the moon only because it reflects light from the sun.

Sunlight is the brightest light we normally see. Summer sunlight can be as bright as 20,000 (near about) candles burning close enough to touch. Bright sunlight seems white, but it is really made up of the colours of the RAINBOW. Issac NEWTON showed this. He made a sunbeam shine through a specially shaped chunk of glass called a prism. Red, orange, yellow, green, blue, prism. The prism had split the sunbeam into separate beams, each with its own wavelength. This is easy to understand if you think of light travelling in waves is the wavelength. We see each wavelength as a different colour. Long waves are red, short waves are violet and wavelengths in between show up as the other colours.

Light travels very fast, more than 3,00,000 km. each second. Even so, it takes eight minutes for the light-from the sun to reach earth. A light year is the distance a beam of light travels in one year. Scientists use light years to measure how far away STARS are. Some are millions of light years away.

You will find the answers about *"Rays of light, Reflection, Refraction, Colours, Capturing in image and many more questions"* by doing the experiments in the next pages.

RAYS OF LIGHT

HOW DOES LIGHT SPREAD ?

Light travels in straight line. If something blocks its path, it can only illuminate the part which is facing it.

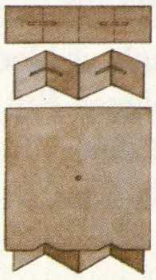
TRY IT YOURSELF

Things you will need

★ Two squares of cardboard ★ A torch
★ Two strips of cardboard ★ A few books

Directions

1. Pierce a hole in the centre of the two cardboard squares. Make supports for each square by folding the cardboard strips and cutting notches, as you see in the picture.

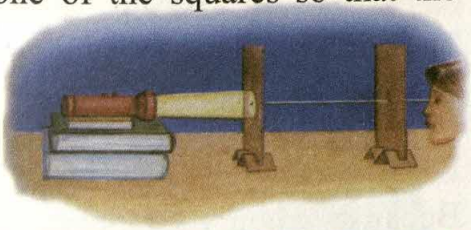


2. Place the squares in the supports and line up the holes. Put the torch on the books, with the light aimed at the hole of the first square. Kneel or sit down so that your eyes are level with the hole in the second square.

Result

Your eye sees the light through the two holes.

3. Move one of the squares so that the holes are no longer lined up.



Result

The eye can no longer see the light.

Reason

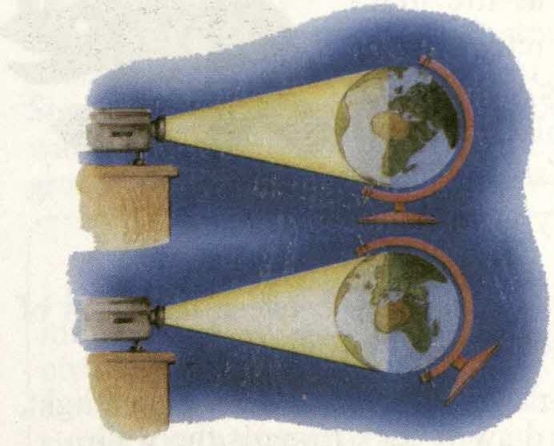
Because light travels in a straight line. So it cannot pass through the hole if it cannot find the end of its path.

Things you will need

★ A globe ★ A portable lamp
★ A darkened room

Directions

1. Point the light directly at the globe.



2. Move the globe downwards, from top to bottom, then side to side, keeping it in the light.

Result

The globe is illuminated only at the part which is turned towards the source of light. The opposite side always remains in the dark, no matter how you hold it.

Reason

Because the rays of light follow a straight path. They cannot curve around an object and light up the side which cannot be seen. That is why the Sun can only shine on one side of the Earth, the side which is turned towards its rays; on the other side of the Earth away from the Sun, there is darkness.

RAYS OF LIGHT

WHAT IS THE REASON FOR SHADOWS ?

When an object blocks out the light, it casts a shadow, which is an area where the rays of light cannot reach.

TRY IT YOURSELF

Things you will need

★ A torch ★ A table lamp ★ A piece of black card ★ Scissors ★ Sticky tape ★ A stick ★ A darkened room

Directions

1. Cut the black card into whatever shape you like. Fix the black shape on to a stick with the sticky tape.

2. Hold the shape between the beam of the torch and the wall of the room.

3. First, bring the shape nearer the light, then draw it back towards the wall.

When the Sun, the Moon and the Earth are in a straight line, there is an eclipse, where the Sun or the Moon is wholly or partly obscured. When the Moon is between the Earth and the Sun, this is a Solar Eclipse. If the Earth comes between the Sun and the Moon, this is a Lunar Eclipse.

Result

The closer the shape is to the torch, the bigger the shadow on the wall. The further the shape is from the torch, the smaller the shadow.

Reason

Because when an object blocks the straight path of the light, a shadow forms behind that object. The closer the object is to the source of the light, the more light it blocks out, and so its shadow is bigger. But if the object is further away, it does not block out much light, and so the shadow is smaller.

4. Shine the lamp on the shape.

Result

The shadow has a more blurred outline than before.

Reason

Because when the source of light is bigger than the object, the shadow which forms is dark at the centre and lighter towards the edges, where only part of the light can reach. The darkest part of the shadow is called the umbra. The area of light shadow is called the penumbra.

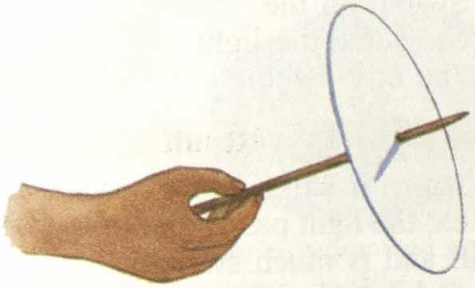
RAYS OF LIGHT

Things you will need

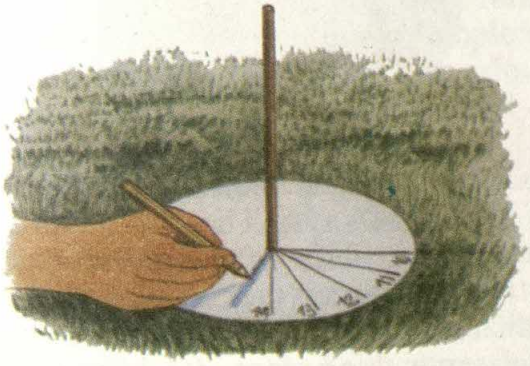
- A cardboard disc, about 20cm in diameter
- A stick about 10-15cm long
- Scissors
- A pencil
- A watch
- A patch of ground where the Sun shines throughout the day.

Directions

1. Make a hole in the centre of the disc. Push the stick through, to about one third of its length. Put in the earth, so that the disc is firmly on the ground.



2. As soon as your watch is on the hour, mark where the shadow of the stick falls on the disc with your pencil. Write down the time beside the line.



3. Do the same thing each hour, remembering to write down the time for each shadow.

Result

The shadow thrown by the stick is in a different position for each hour. The pencil lines spread out from around the stick towards the outer edge of the disc.

Reason

Because the position of the stick's shadow changes as the position of the Sun appears to change. What really happens is that the Earth is rotating at a constant speed, either towards the Sun or away from it.

You have made a sundial, an instrument once used for the measurement of time. Sundials can still be seen today, on the walls of some old houses and in the grounds of ancient squares and gardens.

LIGHT AND SHADOW

Light travels in a straight line, so, in most cases, it can not go around obstacles in its path. When light rays hit a solid object, some bounce back and some are absorbed by the object, warming it up a little. The area behind receives no light rays and is left in shadow.

WHY SHADOWS MOVE ?

Within the space of one day, the position of the Sun in relation to the Earth changes (this is because the Earth is rotating on its axis). Therefore, the direction of the rays of the Sun also changes. That is why shadows **move**. When the Sun is high, it throws short shadows. When it is low on the horizon, the shadows are longer.

RAYS OF LIGHT

DO ALL OBJECTS CAST SHADOWS ?

Only opaque objects block out the rays of light and cast shadows.

TRY IT YOURSELF

Things you will need

★ A torch ★ A book ★ A cup ★ A glass with some water ★ A piece of thin glass ★ A piece of thin paper ★ A handkerchief ★ A piece of tissue paper ★ A darkened room

Directions

1. Line up the objects in front of a wall. Shine the torch on each of them in turn.

Result

Shadows form on the wall behind the cup and the book. Behind the glass of water and the sheet of glass, the wall is lit up. There is a blurred halo behind the tissue paper and the handkerchief.

Reason

Because the cup and the book are *opaque* (cannot be seen through) and so these stop the spread of light. The thin piece of glass and the water are transparent (can be seen through). Materials like the thin paper, the tissue paper and the handkerchief are *translucent* (letting some light through). So they only partially block out the rays of light. The light which remains spreads out to illuminate the wall slightly.

Things you will need

★ A sheet of paper ★ Few drops of oil ★ A drinking straw ★ A torch ★ A darkened room

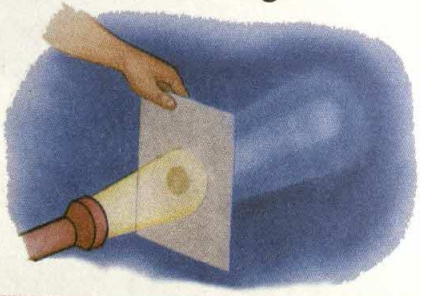
Directions

1. Use the straw to shake one or two drops of oil on the paper.

2. Place the paper between the beam of the torch and the wall.
3. Switch on the torch. Shine the light on the oily patch.

Result

When you shine the torch on the oily patch, the light passes through it on to the wall and is much stronger.



Reason

Because the paper blocks out large parts of the light rays. The oil penetrates through the fibres of the paper, making little transparent (see-through) chinks which allows the light to pass through. The same thing does not happen with water, because this cannot penetrate so easily between the fibres of most types of paper.

REFLECTION

HOW DOES LIGHT ALLOW US TO SEE THINGS ?

We see objects only if the rays of light strikes them, bounces off and then returns to our eyes.

TRY IT YOURSELF

Things you will need

★ A sheet of white paper ★ A sheet of black paper ★ A torch ★ A mirror ★ A darkened room

Directions

1. Switch on the torch in a darkened room and stand in front of a mirror.

2. Hold the torch sideways to your face, so that the light shines on your nose.

3. Take the black paper in your free hand, and then the white paper, looking in the mirror all the time.

Result

The torch by itself only illuminates your nose. But with the black paper, the reflection of your face is almost completely obscured. With the white paper, almost your whole face appears illuminated.

Reason

Because with the torch alone, the light reflects back only from the object it meets, which is your nose. With the paper, the effect depends on the colour. The black paper hardly reflects the light which shines on it. But the white paper reflects a lot of the light, so the rays of light reflect back on to the face, illuminating it.

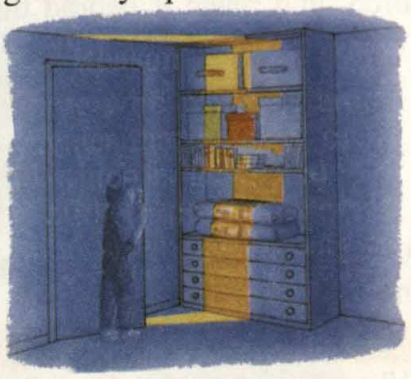
Things you will need

★ A room full of different things (a storeroom, for example)

Directions

1. Go into the darkened room. Close the door and look around.

2. Open the door a little, so that there is only a tiny chink of light. Look around again. Then gradually open the door still more, until it is open wide and look around the room.



Result

When the door is closed, your eyes cannot see the objects in the room. With the first shafts of light, you begin to distinguish the objects a little more. Gradually, as more light enters, you see all the objects clearly.

Reason

Because things are visible only by reflecting the light that is, by the light being sent back to our eyes. Clear objects reflect a lot of light. Darker objects absorb a great deal of light, and so reflect only a little. So we need a lot of light to see darker objects.

REFLECTION

HOW DO MIRRORS WORK ?

Mirrors reflect light in an ordinate way and reproduce the images of things facing them.

TRY IT YOURSELF

Things you will need

★ A piece of strong black cardboard
★ A small mirror, square or rectangular
★ Scissors ★ Torch ★ A darkened room

Directions

1. Fold the piece of cardboard, as shown in the picture. Then cut three slots along one side.

2. In the darkened room, switch on the torch, and place it behind the slots.

3. Place the mirror at the opposite end of the folded card, as shown in the picture.

Result

When the rays of light strike the mirror, each ray bounces back at an angle on the card.

Reason

Because the mirror reflects the light in the ordinary way, with the same angle of reflection with which the ray strikes the mirror (angle of incidence). But if a ray of light strikes the reflective surface in a perpendicular (straight up) direction, it bends itself back along the same path. If a surface is smooth, the light becomes reflected in an ordinate way- that is to say, all the rays go in the same direction. If the surface is rough, then the rays bounce back in a disordinate way.

Things you will need

★ Two flat mirrors

Directions

1. Look into one of the mirrors and move your hand.

Result

Your reflection is shown in reverse if you move your right hand, this will show as the left hand in the mirror.

Directions

2. Place the two mirrors at an angle to each other. Stand between the two.

3. Move a hand.

Result

Your reflection is now correct. The movement of your right hand matches the movement of your right hand in the reflection.

Reason

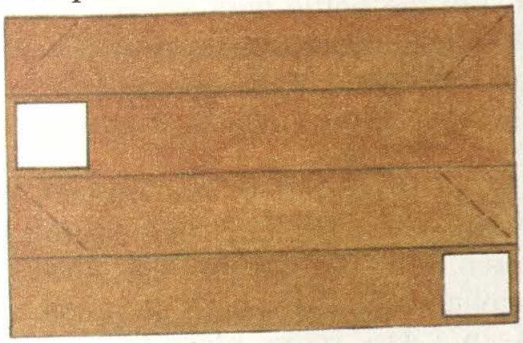
Because the reflected light from your body strikes the mirror in front of you, it bounces back directly, creating the back-to-front image. But when you face two mirrors, each mirror reverses the back-to-front reflection from the other, and so the reflection is 'straightened out'!

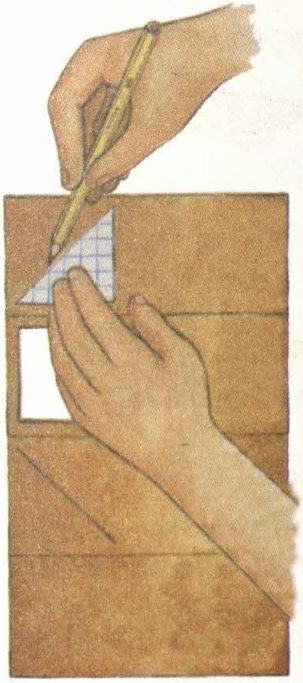
Things you will need

★ A piece of strong cardboard, 32cm x 50cm ★ Scissors ★ Sticky tape ★ Two handbag mirrors, 6cm x 10cm ★ A ruler ★ Pencil ★ Two pieces of cardboard, each 6cm square

Directions

1. Using the ruler, divide the cardboard into four equal parts, each 8cm wide. Draw around a 6cm square twice, as you see in the picture. Cut these squares out.





2. Cut the 6cm square in half diagonally to make two right-angled triangles.

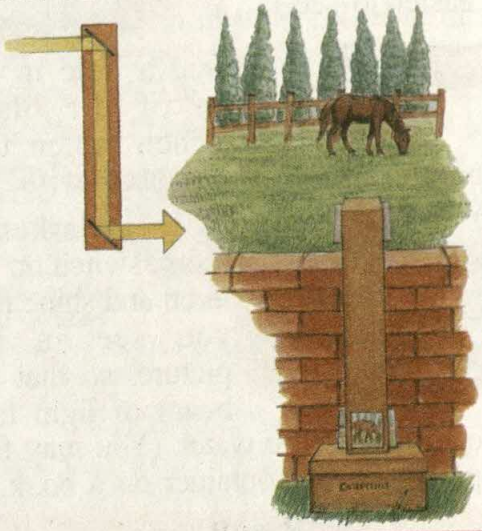
3. Place the triangle on the top strip of the paper, as shown in the picture. Pencil along the diagonal line then cut along this to make a notch. Do this again in the three other places shown in the picture. Fold the cardboard into shape. Join the sides with sticky tape.

4. Thread the two mirrors through the notches.

5. Get behind an obstacle (such as a wall, or a window sill) so that the periscope is sticking up above your head. Look through the square at the bottom.

Result

In the mirror inside the periscope you will see a reflected image of whatever is behind the obstacle.



Reason

Because the light which rebounds from the objects or people on the other side of the obstacle strikes the mirror at the top of the periscope. Because of the angle of this mirror, it is reflected in the bottom mirror. You can use your periscope to look at something without being seen—just like submarine crews who need to survey the sea before coming up to the surface!

REFLECTION

CAN LIGHT BEND ?

Light can pass through curved tubes. These tubes break up its path into little tracks which are always straight.

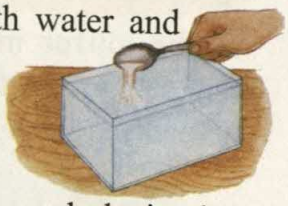
TRY IT YOURSELF

Things you will need

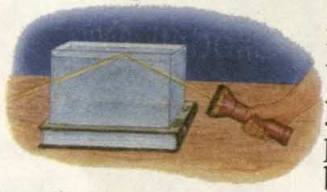
★ A see-through container with flat sides ★ Water ★ A small quantity of milk ★ A torch ★ A piece of black card ★ Scissors ★ Sticky tape ★ A book ★ A darkened room

Directions

1. Fill the container with water and add a few drops of milk. (This makes the rays of light easier to see.)



2. Pierce a hole in the middle of the black card. Then fasten this around the lens of the torch with the sticky tape.



3. In a darkened room, switch on the torch and shine it as you see in the picture, so that the beam of light falls on the surface of the water. (You may find it helps to put the container on a book.)

Result

When it strikes the surface of the water, the light bends and goes out of the container from the opposite side, so that the beam forms an angle.

Reason

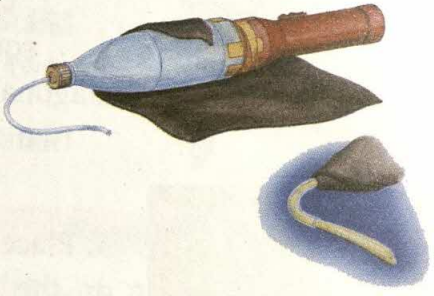
Because light enters the container along a straight path. The surface of the water works like a mirror, and reflects the light. This reflection alters the path of the light, which, in order to stay straight, changes direction.

Things you will need

★ A clear, soft plastic bottle ★ A piece of thin, clear plastic tubing ★ A bowl ★ Plasticine ★ Sticky tape ★ A thick, dark cloth ★ A darkened room ★ Water ★ Scissors

Directions

1. Fill the bottle with water.
2. Ask an adult to make a hole in the cap of the bottle with the scissors. Then thread the tube inside, keeping it firm with plasticine.
3. Fix the torch at the bottom of the bottle with the sticky tape. Switch on the torch. Wrap the whole thing in the cloth, leaving only the tubing uncovered.
4. In a dark room, place the bottle so that a jet of water can be poured smoothly through the tubing and into the bowl.



Result

A jet of luminous water comes out of the bottle.

Reason

Because the light follows the path of water through the curving tube. Inside this tube, the light cannot bend, but is constantly reflected against the walls of the tubing, proceeding in a zig-zag direction because it is trapped inside. This phenomenon is called total internal reflection.

REFRACTION

WHY DOES WATER CHANGE THE IMAGE OF OBJECTS ?

Light from water makes us see different images, or changes the appearance of the real object by the effect of refraction.

TRY IT YOURSELF

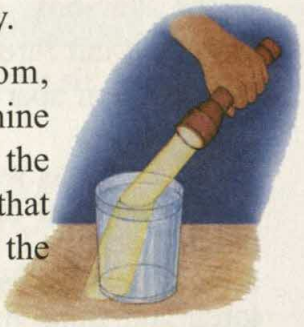
Things you will need

★ A glass ★ Water ★ A little milk
★ A drinking straw ★ A torch
★ A darkened room

Directions

1. Fill the glass with water. Add a little milk to make it cloudy.

2. In a darkened room, switch on the torch. Shine the beam of light from the top to the bottom, so that it shines crookedly on the surface of the water.



Result

When the beam of light enters the water, it changes direction.

Direction

3. Now fill the glass with clean water. Put in the straw.

Result

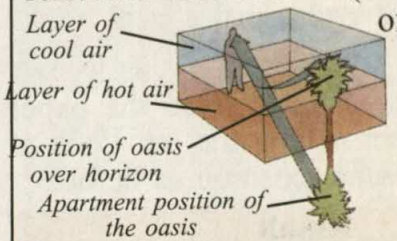
The straw seems to be broken at the point where it enters the water.

Reason

Because when light passes from air to water, and usually from one transparent substance to another, it changes speed, which, in turn, causes a change in direction. We call this *refraction.* This can make an object appear to be in a different position to what it really is. That is why the part of the straw which is under water looks as if it has moved away from the part above water.

MIRAGE

In the hot desert, weary travellers are often fooled by the side of an oasis (a fertile area where water rises to the surface). The oasis appears on the horizon, only to vanish as the travellers hurry towards it. What they have seen is an illusion called a mirage. The oasis may exist but it lies beyond the horizon. The light from the oasis is reflected and refracted (bent) by a layer of hot air near the ground, making the oasis look closer than it really is.



DIFFERENT DEPTH

Have you ever noticed that pools and ponds are always deeper than they look? This is because light is refracted as it leaves the water, making the bottom of the pool appear closer than it really is. You can see this effect in this glass of water. Light rays are refracted in such a way as to make the button look closer than it really is.

Light rays from the button are refracted as they leave the water. You see the button as though the light rays were travelling in a straight line.

REFRACTION

HOW DO LENSES WORK ?

Lenses have curved surfaces, so that the light can make objects appear bigger or smaller.

TRY IT YOURSELF

Things you will need

★ A round, glass jar ★ Paper with a pattern on it ★ A drinking straw ★ Water

Directions

1. Fill the jar with water. Put the straw in it, keeping it up straight. Look carefully at the top of the water.

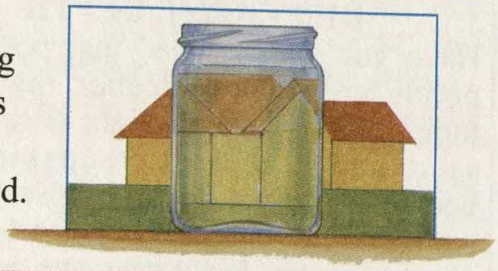
Result

The part of the straw in the water looks larger.

2. Take out the straw. Place the paper with the pattern behind the jar. Look at this from the same position as before.

Result

The drawing appears to be enlarged.



Reason

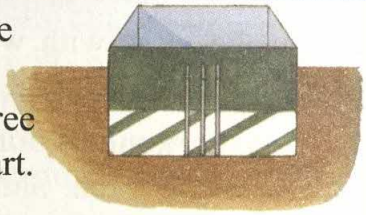
In the passage from water to air, the rays of light become refracted (change direction). If the surface of separation (e.g. the jar or a glass) is curved, the refraction makes the object look bigger than it actually is.

Things you will need

★ A shoe-box ★ A glass ★ Water ★ A torch ★ A pencil ★ Ruler ★ Scissors ★ A darkened room

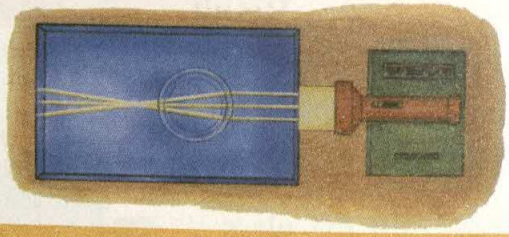
Directions

1. In a short side of the shoe-box, draw and cut three notches 1cm apart.



2. Fill the glass with water and place this in the centre of the box, in line with the notches.

3. In the darkened room, switch on the torch and shine it on to the notches.



Result

Because meeting the glass of water, the rays of light are parallel. But after passing through the glass, they meet at a certain point (to obtain this effect, you may have to move the glass). At the point where the rays of light meet they are stronger.

Reason

Because the curved surface of the glass and the water causes refraction of the rays of light, making them meet together and then cross over.

REFRACTION

Things you will need

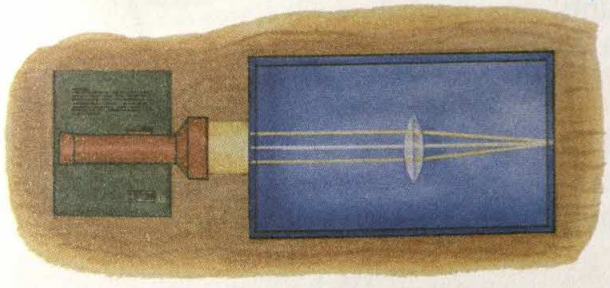
★ The shoe-box used in the last experiment
★ Scissors
★ A convex lens (with the surface curving outwards)
★ A concave lens (with the surface curving inwards)
★ A sheet of white paper
★ A torch
★ A darkened room

Directions

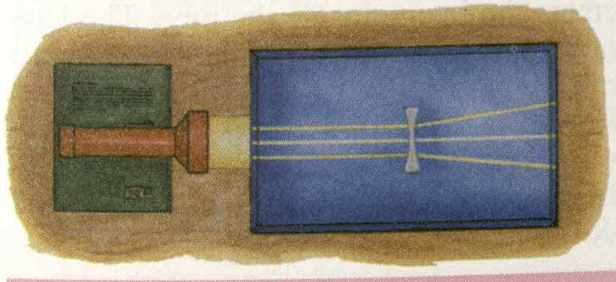
1. Cover the bottom of the shoe-box with the white paper.

2. With the scissors, make a notch at the bottom of the box in which you can put one of the lenses to look through.

3. Place the convex lens in the notch. In the dark, set the torch against the upright notches.



4. Repeat stage 3, using the concave lens.



Result

The rays which pass through the convex lens change direction and meet at a point. The rays which pass through the concave lens spread out from each other.

Reason

Because the different shape of the lenses cause a different angle of refraction. Convex lenses bring the rays of light closer together. These can be used to see objects bigger, or smaller, according to the distance of the object from the lens. The concave lens causes a separation of the beam of light. If this is put between the eye and the object, it will make the object appear smaller.

SPECTACLES

Inside the human eye, there is a lens called the crystalline lens. This enables people to see images both near and at a distance. If the crystalline lens does not work properly, vision can be corrected by the use of external lenses—spectacles or contact lenses enable short-sighted people to see better at a distance, and long-sighted people to see closer. They can also make images clearer for people whose eyes cannot focus properly.

With the some people, the rays of light passing into their eyes do not bend enough to make a clear picture. With others, the rays may bend too much. The lenses in spectacles help people to see more clearly by correcting the amount the rays are bent.

REFRACTION

HOW DOES A TELESCOPE BRING AN IMAGE CLOSER ?

Telescopes make distant objects appear nearer, using a combination of lenses and mirrors.

TRY IT YOURSELF

Things you will need

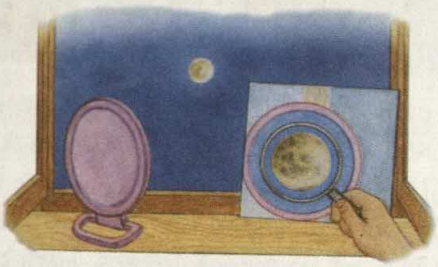
★ A concave mirror (such as a shaving mirror) ★ A plain mirror ★ A magnifying glass ★ A window

This experiment must be done at night when the Moon can be seen through the window.

Directions

1. Place the shaving mirror in front of the window, turned towards the Moon.

2. Stand in front of the window and slowly turn the plain mirror towards you, so that you can see the image of the Moon reflected in the shaving mirror. Look through the magnifying glass at the image of the Moon which appears in the plain mirror.



Result

In the plain mirror, the Moon appears to be nearer and you can make the image larger with the magnifying glass.

Reason

Because the concave mirror reflects and brings nearer the image of the Moon. The plain mirror, not being curved, reflects the image exactly and bounces it back through the magnifying glass. This makes the image larger. Telescope work in the same way, by using reflection.

Things you will need

★ Two magnifying glasses ★ Two cardboard tubes of different diameters ★ Sticky tape

Directions

1. Slide one tube into the other. Fix a magnifying glass at one end with sticky tape.

2. Look at the Moon through the tubes, with your eye against the taped magnifying glass and holding the second glass at the other end. Make the tube longer and shorter and move the second glass until you get a clear image.

Result

Through the taped magnifying glass, you can obtain a closer image of the Moon, but upside down.

Reason

Because the lens at the end make the rays of light from the Moon converge and create the image inside the tube. The lens nearest the eye enlarges this image and makes the Moon appear closer.

Refractor telescopes work in the same way, but these are much larger in order to show images which are not upside down.

COLOURS

WHAT COLOUR IS LIGHT ?

Light appears to be white, but it is made up of the seven colours of the rainbow, or the colour spectrum.

TRY IT YOURSELF

Things you will need

★ A piece of white card ★ A short pencil with a sharp point ★ A protractor ★ Felt-tipped pens ★ Geometry compass ★ Scissors

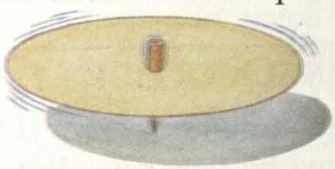
Directions

1. Set the compass at 5cm radius to draw a 10cm diameter circle on the card. Cut out.

2. Using the protractor, divide the cardboard circle into 7 equal sections, with each section at about 51^0.

3. Colour the sections in this order; red, orange, yellow, green, sky blue, indigo and violet.

4. Thread the pencil through the centre of the circle with the point at the bottom.



5. Spin the circle, as if it were a spinning top.

Result

While the top is spinning, the colours cannot be picked out. The circle seems almost white.

Reason

Because with the fast rotation, all the seven colours which you have used become mixed together, resulting in a whitish colour.

Things you will need

★ A torch ★ A shallow rectangular container ★ A plain mirror ★ Piece of white card ★ Water

Directions

1. Fill the container with water.

2. Put the mirror in the water, and slowly lean it at an angle against a short side of the container.

3. Shine the torch on the water so that the beam lights up the part of the mirror which is under the water.

4. Place the white card in front of the mirror to catch the reflected light.

Result

The white card catches a reflection with the colours of the rainbow.

Reason

Because the beam of light reflected on the mirror, as it escapes from the water, becomes refracted. But the colours which comprise the white light are not refracted at the same angle, and so they fall at different points and become visible.

COLOURS

HOW ARE COLOURS FORMED ?

By mixing two primary colours together, we obtain other colours, which are called secondary colours.

TRY IT YOURSELF

Things you will need

★ Two torches ★ Two pieces of see-through plastic (one red, one green) ★ Two elastic bands ★ A piece of white card ★ Green, red, yellow and blue paints ★ A paint-brush ★ A plate

Directions

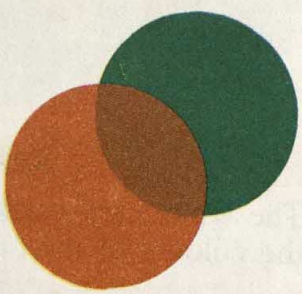
1. Use the elastic bands to fix a piece of plastic to each torch.

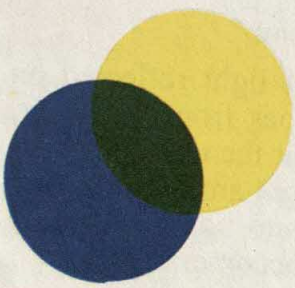
2. Switch on the torches. Shine them on the white card, overlapping the two beams of light.

Result

The place where the two beams overlap appears yellow.

3. Mix an equal quantity of red and green paint on the plate with the brush.





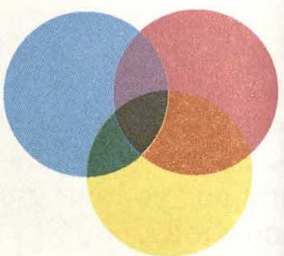
4. Wash out the brush. Then do the same with the yellow and blue paint.

Result

Mixing the red and green paint makes a colour rather like maroon. The yellow and blue paints make green.

Reason

Because from the primary colours of sunlight - green, red and blue - which you mixed two at a time, originates all other colours, (secondary colours). The pigments of primary colours (used in paint, varnishes, inks, etc.) are magenta red, cyan blue (greenish blue) and yellow. From the three primary colours of light together, we can obtain white light; and from all these, together with the three primary colour pigments, we obtain a very dark colour which is almost black.



HOW DO WE SEE COLOURS ?

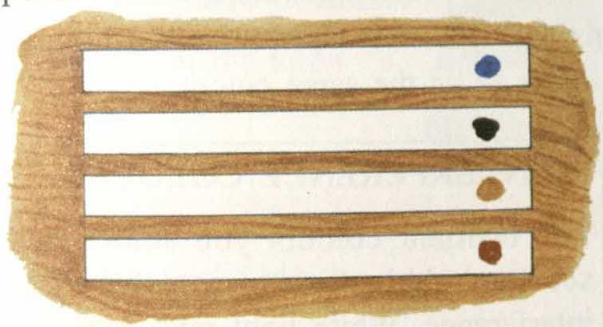
We can see things around us only if they are illuminated by light rays. But the light which strikes an object is partly reflected towards our eyes. The colour of an object depends on the colour of the light which it reflects. An apple appears red because it reflects only the red colour and absorbs all the other colours. White objects reflect the light completely, whilst black object absorb almost all the light.

Things you will need

★ A bottle of coloured ink, or felt-tipped pens of different colours (including black)
★ A large, flat dish
★ Water
★ Strips of white toilet paper, 20cm long and 2-3cm wide.

Directions

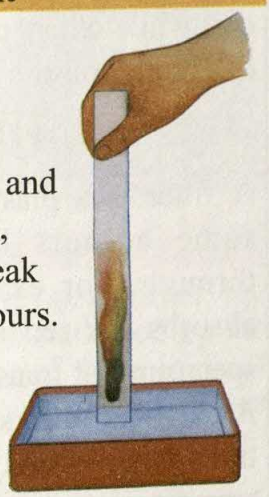
1. Let one or two drops of ink fall on each strip, at about 2cm from the bottom. Or make a blot with one of the felt-tipped pens.



2. Pour a little water into the dish, and dip the end of each strip (one at a time) into the water. Wait until the water reaches the inky patch.

Result

The water gets dirty and some of the blots, including black, break up into different colours.

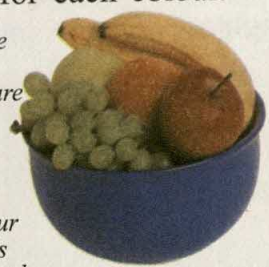


Reason

Because the water dissolves (that means it breaks up) the pigment which, according to the colour, moves through the water at a different speed. This means that the colours separate and each one begins to reflect its own colour. This experiment will enable you to distinguish which of the inks and felt-tipped pens are made up of the most colours, and which ones are composed of only one colour.

COLOUR ON TELEVISION, COLOUR ON PAPER

The images we see on television are composed of tiny little lines of the three primary colours of light (red, green and blue). The eye **mixes** them and sees clear images in all the colours. For printing books and magazines we use the primary pigment colours (yellow, magenta red, and cyan) as well as black to make the images more definite. Until recently, each page had to go through the printing machine once for each colour. Now one-stage, multi-colour printing is widespread. Mixing these colours in different proportions produce all the different colours you can see. When a book or magazine is prepared for printing, the colour images are scanned to separate the four colours photographically. The films are used to prepare a printing plate for each colour.



When the colour images are printed on top of each other, a full-colour picture is reproduced.

Black is treated as a separate colour so that text and outlines are reproduced sharply.

COLOURS

CAN WE COLOUR WHITE LIGHT ?

When light is coloured, the colour acts as a filter, blocking out all the colours of the spectrum except its own.

TRY IT YOURSELF

Things you will need

- ★ A piece of white paper
- ★ Felt-tipped pens
- ★ A piece of see-through red plastic

Directions

1. With the felt-tipped pens, make blots of different colours on the paper.

2. Look at all the colours together through the red plastic

Result

The piece of paper appears to be completely red. You will be able to pick out only the brightest blots.

Reason

Because the plastic acts as a filter. It lets through only the red light, and absorbs all the other colours. In the same way, a coloured filter placed in front of a spotlight or torch blocks out all the colours of white light except its own. So the light which is allowed to pass through seems to be the same colour.

INTERFERENCE COLOURS

The brilliant colours you sometimes see on bubbles are caused by light interference. White light rays reflected from the inside of the soap film travel slightly further than those reflected from the outside. The waves in each ray interfere with each other where they meet. Some colours cancel each other out, while others combine to form bands of colours on the surface of the bubble.

FILTERS

A filter is a plastic sheet that absorbs some colours but lets other pass through. For example, a green filter absorbs the red and blue parts of the spectrum but transmits the green region. A magenta filter absorbs green light and transmits red and blue.

COLOURS

WHY DOES THE SKY CHANGE COLOUR ?

The sky changes colour because the atmosphere spreads the light in a different way according to the position of the Sun.

TRY IT YOURSELF

Things you will need

★ A large see-through vase. ★ Water
★ Milk ★ A torch

Directions

1. Fill the vase with water. Add a few drops of milk.

2. Switch on the torch and shine it down into the water.

Result

The water looks bluish.

3. Point the torch on the outside of the vase. Go to the other side and look at the light through the water.

Result

The water takes on a colour which is rather pink, whilst the part which is illuminated appears yellowish orange.

Reason

Because changing the position of the beam of light, the water, darkened by the milk, causes a refraction of the colours of light. In the same way, the atmosphere reflects the rays of the Sun, according to its position in relation to the Earth.

THE COLOURS OF THE SUN AND THE SKY

When the sun is high it appears yellow, and the sky, if it is a calm day, appears blue, because the atmosphere filters out all the other colours. When the sun at dawn is low, it looks red and the sky is pink, red and yellow. With the luminous rays of light coming at this angle, the colours of the spectrum become merged into the atmosphere.

Blue sky

When rays of light travel through the atmosphere, they hit pollen, dust, and other tiny particles. This causes the rays to scatter, or bounce off in all directions. Some colours of light are scattered more than others.
The atmosphere scatters mainly blue light; this is why the sky looks blue. The other colours of light are scattered much less than blue so that they come to Earth directly. This causes the area of sky around the sun to look yellow.

Sunset and Sunrise

At sunset and sunrise, when the sun is below the horizon, the light travels through much more of the atmosphere before we see it. The blue light is scattered so much that it is absorbed, or soaked up, by the atmosphere. Only red light reaches us, so the sky looks red.

COLOURS

WHY DOES THE COLOUR BLACK ATTRACT HEAT ?

Black objects completely absorb sunlight. Some of this absorption is converted into heat.

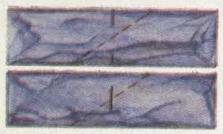
TRY IT YOURSELF

Things you will need

★ A piece of thick aluminium foil ★ An all-surface black marker pen ★ Scissors ★ A ruler ★ Pencil ★ Sticky tape ★ Thread ★ Large, clear glass jar ★ Piece of strong card, larger than the opening of the jar.

Directions

1. Cut two strips of aluminium foil each 10cm x 2.5cm.



2. With the scissors, cut notches (shown as black lines in the picture).

3. Colour one side of each strip black. Then fold as shown in the picture so that the black side is inside the fold.

4. Place one strip underneath the other and fasten with sticky tape. Thread cotton through the card, as shown in the picture.

5. Hang the strips inside the jar, with the card as a cover. Then put the whole thing in direct sunlight.

Result

When the jar has warmed up, the 'sails' begin to turn slowly.

Reason

Because the black side of the sails absorb more light than the silver, which reflects the light. So the black sails gets even hotter. As they warm the air around them, this warm air spreads out and pushes against the sails, making them turn.

Things you will need

★ Two glass containers ★ Water ★ A piece of black material ★ A thermometer

Directions

1. Fill the two containers with water.

2. Cover one of them with the black cloth.

3. Put the two containers in direct sunlight and check the temperature each half hour.

Result

The temperature of the water in the jar covered by the black cloth increases more quickly.

Reason

Because the black cloth almost completely absorbs the light, whilst the surface of the water merely reflects it. The light absorbed by the black cloth is transformed into heat. This warms up both the air around it and the water underneath it, more than it would be in the open air. That is why wearing black clothes when it is sunny makes us feel hotter than if we were wearing clear colours or white.

CAPTURING AN IMAGE

HOW DOES THE HUMAN EYE SEE ?

The images of illuminated objects become projected on to the inside of the eye through the pupil.

TRY IT YOURSELF

Things you will need

★ Clear glass bowl (like a goldfish bowl) ★ A table lamp ★ A piece of card which is black on both sides. ★ A piece of white card. ★ Scissors ★ Water ★ A darkened room

Directions

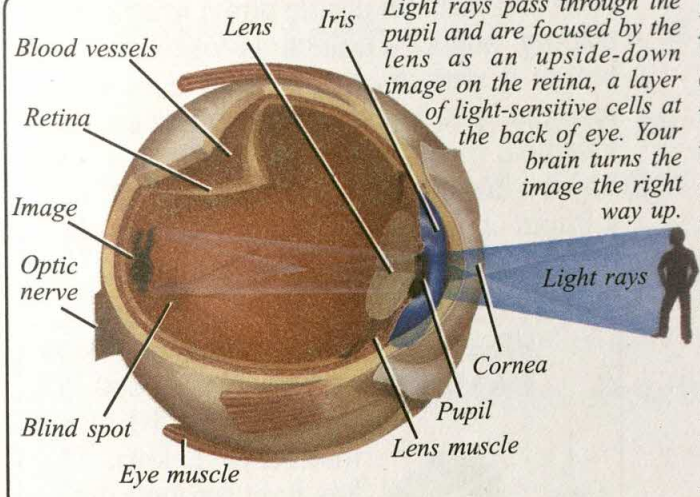
1. Fill the bowl with water.
2. With the scissors make a small hole at the centre of the black card. Place this against the glass bowl.
3. Place the white card opposite so that it faces the bowl.
4. Darken the room and switch on the table lamp. Line this up in front of the black card, so that the beam of light is the same height as the hole.

Result

On the white card there appears an image of the lamp, but upside down.

Reason

Because the light from the table lamp enters through the hole of the black card and becomes refracted through the bowl of water, which works like a lens. When the refracted light shines on the white card it reproduces an image of the lamp, but upside down.



HOW OUR EYES WORK

The pupil in our eye works like the hole in the car. It lets in the luminous light reflected by objects. On the inside of the eye, the light rays meet the crystalline lens (represented in the experiment by the bowl full of water) which works as convex lens and brings the rays together to pass through it. These rays then strike the retina at the back of the eye. This is a sort of screen on which the image is projected, but smaller and upside down (in the experiment, the retina is represented by the white card).

Why are images projected upside down?

Because the rays of light which enter through the pupil travel in a straight line. As they converge through the crystalline lens, they cross over, changing their positions. But our brain *straightens them up* through the impulses of the optic nerve at the back of the eye so that we see the image correctly.

CAPTURING AN IMAGE

HOW DOES A CAMERA WORK ?

Through the camera lens, the image of objects in the light is projected and impressed on photographic film.

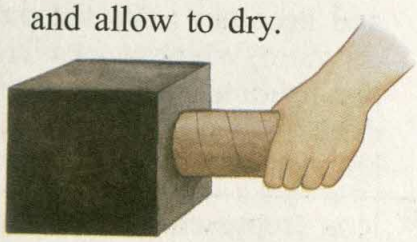
TRY IT YOURSELF

Things you will need

★ A square shaped box without a cover ★ A cardboard tube ★ A magnifying glass ★ A piece of tracing paper ★ scissors ★ Sticky tape ★ Black paint ★ A paint brush

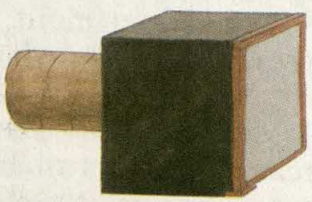
Directions

1. Paint the box black and allow to dry.

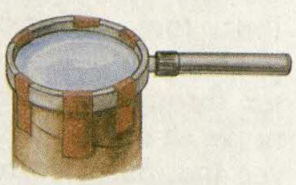


2. Draw around the tube on to the base of the box with a pencil. Cut inside the pencil line with scissors. Push the tube into the box.

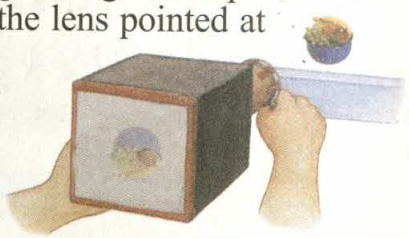
3. Use the sticky tape to fix the piece of tracing paper over the opening of the box, in place of a cover.



4. Fix the magnifying glass with sticky tape at the opening of the cardboard tube.



5. Aim the whole thing towards an object which is in a good light. Keep the end of the tube with the lens pointed at the object, and the part with the tracing paper towards you.



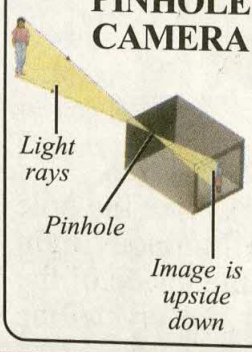
Result

On the tracing paper you see an image of the object, but small and upside down. (You will be able to make the image clearer by moving the tube.)

Reason

Because the magnifying glass, which is convex, makes the rays of light converge on the inside of the box. The rays cross each other and form an upside down image on the tracing paper. Thousands of years ago, before it was discovered that eyes do not give out light, boxes similar to this one were invented, in which the light reflected by an object entered simply through a hole, without a lens. The image of the object reproduced on a sheet of paper was then observed with much wonder.

PINHOLE CAMERA



The simplest possible camera is a closed box with a small hole instead of a lens. This lets light through onto a screen at the back of the box. The image can be quite fuzzy and long exposure times are needed.

MAGNETISM

A magnet attracts some metals, particularly iron and steel. The earth is a huge natural magnet. Invisible lines of magnetic force spread out around the planet, joining the north and south magnetic poles. We call this the earth's magnetic field.

The needle in a COMPASS is a magnet. It always turns to face magnetic north. In ancient times people noticed that a kind of iron are called a lodestone suspended from a string would always swing in the same direction. A lodestone is a natural magnet. Another name for it is magnetite.

An electromagnet is made by coiling wire around a metal core and passing electricity through the coil.

You will find the answers about *"The magnet, Magnetic Poles, Magnetic Force, Magnetism and Electricity and many other questions"* by doing the experiments in the following pages.

MAGNETS

CAN MAGNETS ATTRACT ANYTHING ?

Magnets exert their power of attraction on objects of iron, steel and other metals.

TRY IT YOURSELF

Things you will need

★ Things made of different materials : iron, wood, glass, plastic, steel, fabric, paper.

★ Different surfaces : the door of a refrigerator and a wardrobe, a wall, a window pane.....

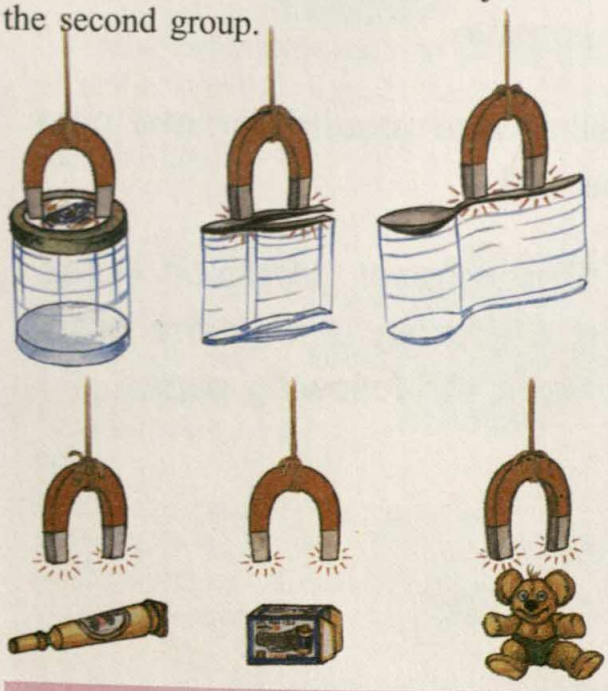
★ A magnet tied to a thread.

Directions

1. Divide the objects into two groups: metal and non-metal.

2. Hold the magnet close to the objects in the first group, one at a time.

3. Now do the same with the objects in the second group.



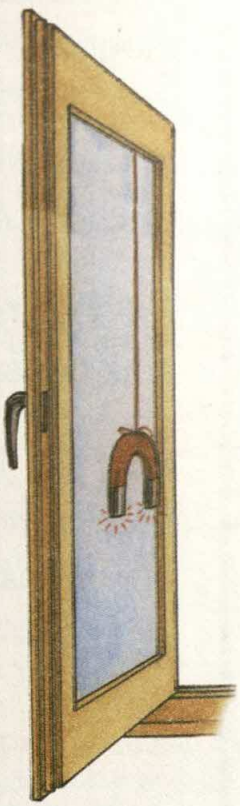
4. Hold the magnet close to the surface of the refrigerator, the wardrobe, the wall and the window.

Result

Some metal objects attach themselves to the magnet. Others do not. The non-metal objects are not attracted. The magnet is attracted to some surfaces, but not to others.

Reason

Magnets are pieces of steel or iron which have a special ability to attract objects made from steel, iron, nickel, cobalt, chrome, or materials which contain a small amount of any of these metals. Wood, glass, plastic, paper and fabrics are not drawn to the force of the magnet. The force of attraction between the magnet and a large-size steel surface makes the magnet move towards the surface, because the magnet weighs less than the surface.



CAN MAGNETS WORK THROUGH SUBSTANCES ?

Magnetic force can pass through objects and substances.

TRY IT YOURSELF

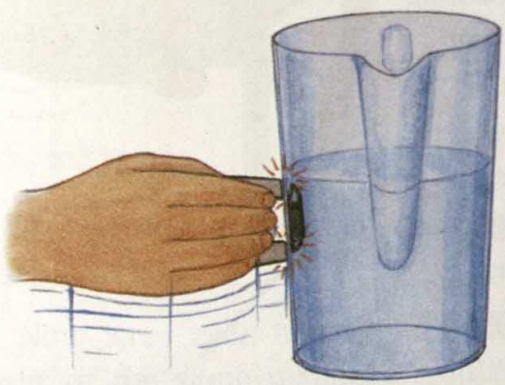
Things you will need

- A magnet
- A jug
- A paper-clip
- Water

Directions

1. Pour water into the jug and drop in the paper-clip. Then invite a friend to take the paper-clip out, but without putting a hand in the water.

2. Place the magnet on the outside of the jug, on the side of the paper-clip. When this moves towards the magnet, draw the magnet slowly up towards the top.



Result

The paper-clip follows the movement of the magnet until it is above the level of the water. In this way, it is possible to take it out without getting your hand wet!

Reason

The force of the magnet also works through the glass of water. If the sides of the jug were iron or steel, the paper-clip would still be drawn to the magnet, but with a lesser intensity, because part of the magnetic force would be 'absorbed' by the sides of the jug.

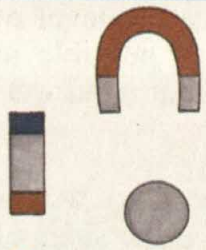
UNDER WATER MAGNETS

Magnets are widely used during the construction and the repair of underwater installations. For example, this diver is under the sea, checking part of an oil rig for damage. The cables used in these tests are held in place by the red magnets. These stick to the steel rig, even though it is deep under water. Engineers use magnets to hold instruments and equipment in a safe place, and for holding parts of the installation in position during work.

Things you will need

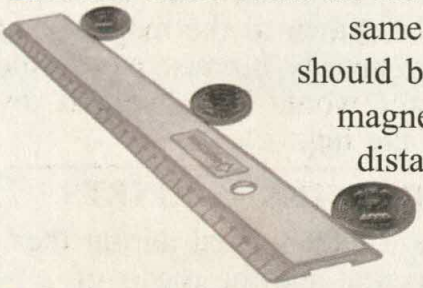
★ Three magnets of different sizes.
★ Some objects of iron or steel (coins, for example) ★ A table ★ A ruler

Directions



1. Place the things on the table about 10cm apart.

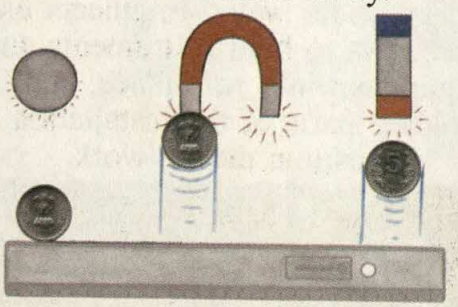
2. Place some coins on the table in the same way. These should be facing the magnet, but some distance from it.



3. Using the ruler, gradually push the coins closer and closer to the magnets.

Result

Some of the coins are attracted by the magnets almost at once, others only when they are a short distance away.

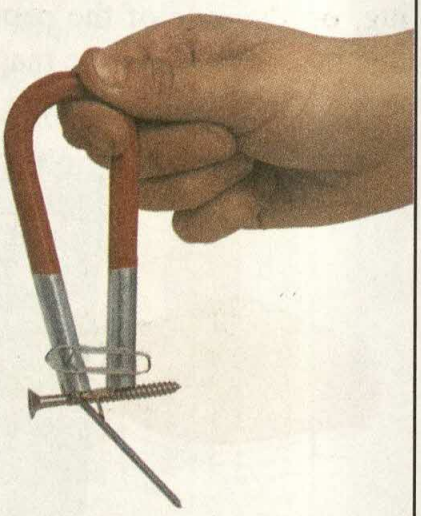


Reason

Because magnets can exert their force at a distance from things. The larger the magnet, the stronger its force and the greater the distance at which it can attract objects.

MAGNETS

Cut a magnet in half, and you get new magnets, each with North and South poles. Cut it in half again and you get two more magnets. In fact, no matter how often you divide a magnet, up to a point, you always get new magnets. Knows quite why, but it is thought that all magnetic materials are made up of tiny groups of atoms called *domains,* each like a mini-magnet with its own North and South pole. In any iron or steel bar, there are many of these domains. When the bar is unmagnetized, these poles point randomly in any direction. But when you put a magnet nearby, they all begin to point the same way. In steel, once they are all lined up, they tend to stay that way, and the steel becomes a permanent magnet. It only loses it magnetism if the domains are jumbled up again—perhaps by hitting with a hammer or heating red hot Iron, however, loses its magnetism almost instantly.



MAGNETS

WHAT CAN BLOCK OUT THE FORCE OF A MAGNET ?

The force of a magnet can be neutralized by a thick layer of non-magnetic material.

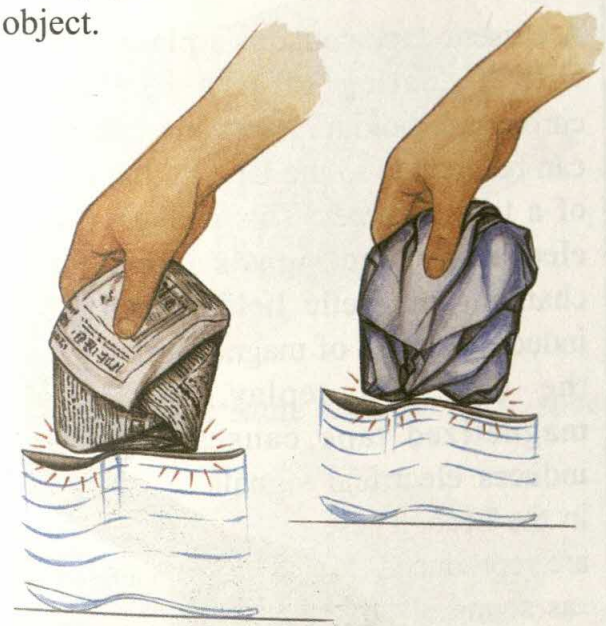
TRY IT YOURSELF

Things you will need

- Some sheets of newspaper
- Piece of aluminium foil
- Bits of material
- Some foam rubber
- A large magnet
- Something made of iron

Directions

1. Wrap the magnet in a sheet of newspaper. Then try to attract the iron object.



2. Do the same thing with the other materials.

3. Now wrap each magnet in a second layer of the same material. Add more layers, until the force of the magnet weakens and then stops.

Result

The magnet attracts the object through one thin layer of material. But as the thickness of layers increases, it can no longer exert its force.

Reason

Although the magnetic force can go through a thin layer of material, it cannot pass through thick layers. This experiment shows that the magnet can be isolated, in order to avoid it affecting substances which need to be protected from magnetic attraction.

MAGNETS

WHAT DOES THE POWER OF A MAGNET DEPEND ON ?

The strength of a magnet is linked to its shape and its size.

TRY IT YOURSELF

Things you will need

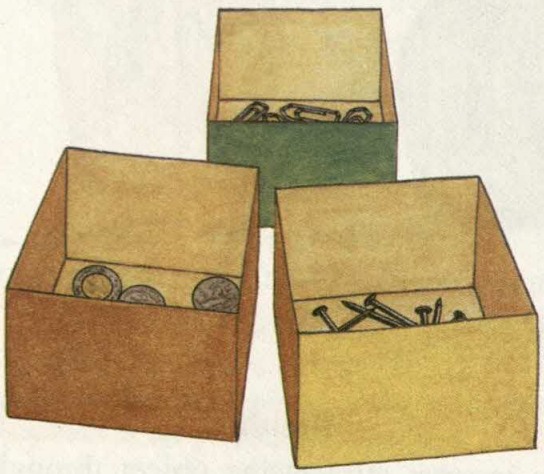
★ Magnets of different shapes (horse-shoe, bar, round) and different sizes.

★ Things made of iron or steel (paper-clips, coins, nails)

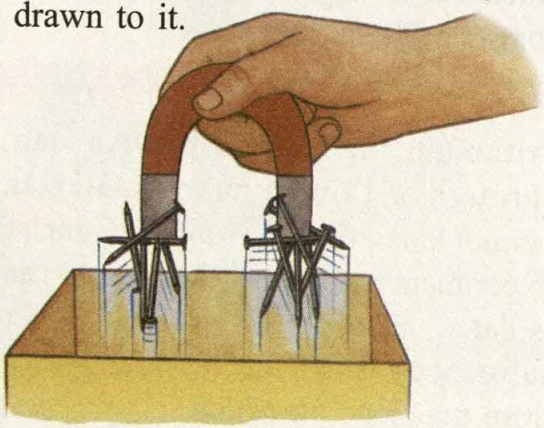
★ Cardboard boxes

Directions

1. Sort the things into boxes.



2. Hold the magnet over each box in turn, and count how many of the same objects are drawn to it.



Result

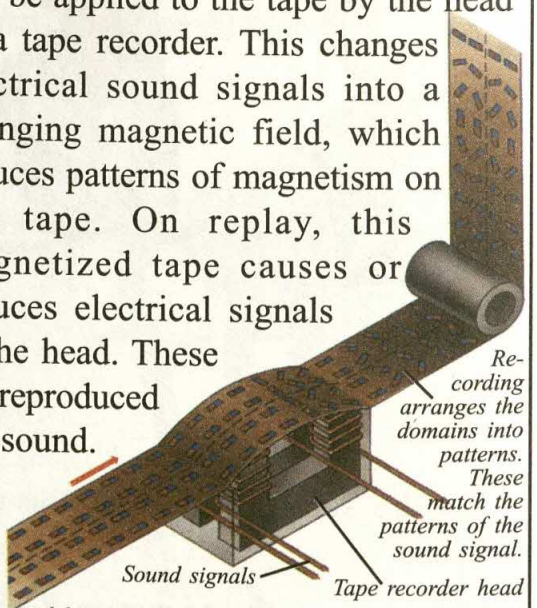
Some magnets attract more objects than others.

Reason

The shape of a magnet influence its power. An iron horse-shoe magnet is more powerful than a bar magnet, which, in turn, is more powerful than a round magnet. With magnets of the same shape, the larger the magnet, the more powerful it is.

MAGNETIC TAPE

A cassette tape contains a plastic tape with a coating of iron oxide or chromium dioxide. Magnetic patterns can be applied to the tape by the head of a tape recorder. This changes electrical sound signals into a changing magnetic field, which induces patterns of magnetism on the tape. On replay, this magnetized tape causes or induces electrical signals in the head. These are reproduced as sound.



Tape erased by high-frequency alternating magnetic field. The inaudible high-frequency signal replaces any previously recorded sound signals on the tape.

THE MAGNETIC POLES

DO ALL PARTS OF A MAGNET HAVE THE SAME FORCE ?

The magnetism exerted by a magnet is more intense at its ends, which we call the magnetic poles.

TRY IT YOURSELF

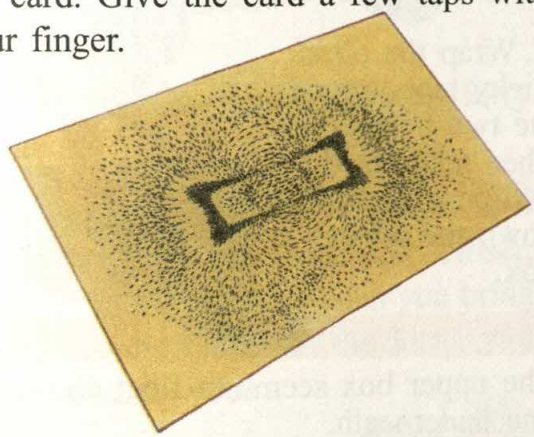
Things you will need

- ★ Iron filings (obtainable from a workshop, or by filing a piece of iron)
- ★ A bar magnet
- ★ A horse-shoe magnet
- ★ Two postcards

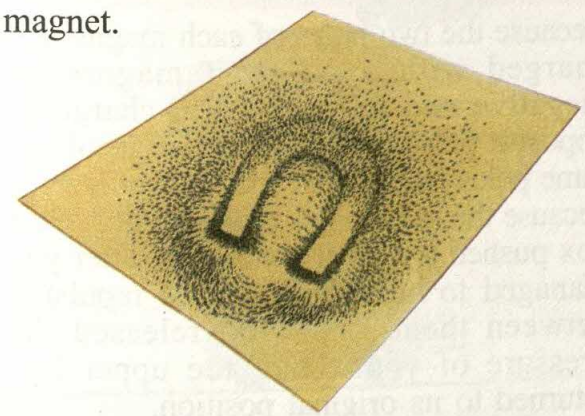
Directions

1. Place one postcard on the bar magnet.

2. Gradually sprinkle the iron filings on the card. Give the card a few taps with your finger.



3. Now do the same with the horse-shoe magnet.



Result

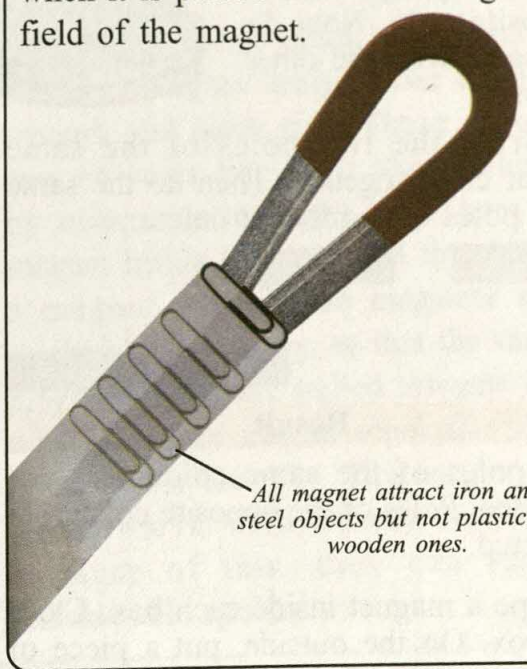
Most of the iron filings are centered around the outside of the magnet. A lesser amount is scattered around.

Reason

The magnetic force of a magnet is concentrated at the poles, meaning the ends of the magnet. Away from the poles, the magnetism is not so strong.

MAGNETIC FIELD

The area around a magnet in which its magnetic force works is called its magnetic field. For instance, a paper clip is pulled towards the magnet when it is placed within the magnetic field of the magnet.



All magnet attract iron and steel objects but not plastic or wooden ones.

THE MAGNETIC POLES

WHY DO TWO MAGNETS SOMETIMES REPEL (PUSH APART)?

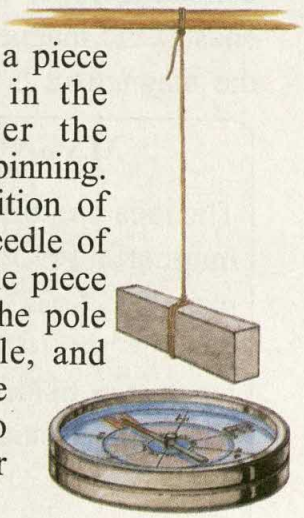
The opposite poles of two magnets attract each other. Two of the same poles repel each other.

TRY IT YOURSELF

Things you will need

★ Two bar magnets ★ Sticky tape in red, blue and transparent ★ A compass ★ Two cardboard boxes of the same size ★ Scissors ★ Two pencils ★ String

Directions



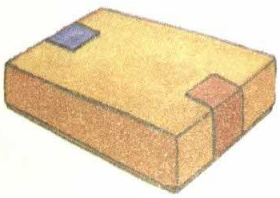
1. Tie a magnet on to a piece of string, as shown in the picture. Hold it over the compass until it stops spinning. Then compare the position of the magnet with the needle of the compass. Put a little piece of red sticky tape on the pole indicated by the needle, and blue sticky tape on the opposite pole. Now do the same with the other magnet.

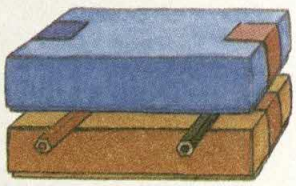
2. Bring the two poles of the same colour close together. Then do the same with poles of a different colour.

Result

The poles of the same colour are not attracted. Poles of the opposite colour are attracted.

3. Tape a magnet inside each box. Close the box. On the outside, put a piece of blue or red sticky tape to match with the two poles of the magnet inside.





4. Place the two pencils on one of the boxes. Put the second box on top of the pencils, matching the marks of the same colours at the ends.

5. Wrap the clear sticky tape around the two boxes. Then take out the two pencils. Press down the upper box.

Result

The upper box seems to float above the one underneath.

Reason

Because the two poles of each magnet are charged with a different magnetism (negative and positive). The charge of opposite poles attract. The charge of the same poles repel (push apart). That is why, because the same poles corresponded, each box pushed the other away. And after you managed to beat this force of repulsion between them, once you released the pressure of your hand, the upper box returned to its original position.

MAGNETISM

THE MAGNETIC POLES

Things you will need

- Two bar magnets with opposite poles (see last experiment)
- A toy lorry
- Sticky tape

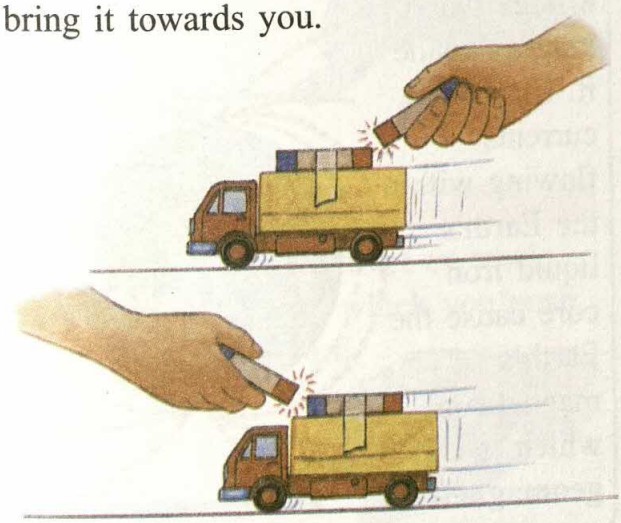
Directions

1. Fix the bar magnet on the lorry with the sticky tape.

2. Use the other magnet to draw the lorry towards it.

Result

When you bring the same pole closer, you push the lorry away. When you bring a different pole closer to the lorry, you bring it towards you.



Reason

Because the movement of the lorry is determined by the magnetic force which draws in two directions-towards the magnet which you have in your hand (two different poles attract each other) and in the opposite direction (two poles of the same repel each other). You can use this experiment to play games with your friends.

MAGLEV TRAINS

(TRAINS WITHOUT WHEELS)

Some high speed trains do not have wheels. Maglev trains give a very smooth and quiet ride. These do not run on rails but *float* above them by using electromagnetism. There is magnet inside the train and the rail is a magnet, too. These magnets are worked by electricity, so that the same magnetic poles are pulled towards the other, so as the magnet repel, the train *floats* above the rails. This means the trains move without any friction. Because of this, they can reach considerable speeds.

THE MAGNETIC POLES

WHAT MAKES THE NEEDLE OF A COMPASS MOVE ?

Earth acts like an enormous magnet. It attracts any magnetic needle which is free to move.

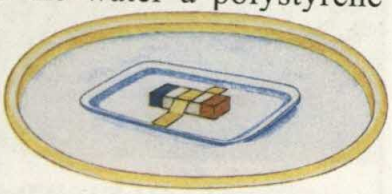
TRY IT YOURSELF

Things you will need

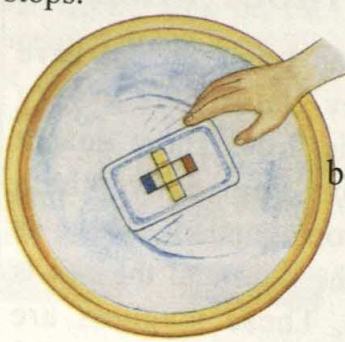
★ A bowl ★ Water ★ A bar magnet ★ A flat polystyrene tray (smaller than the bowl; it must be able to move on the surface of the water without hitting the sides of the bowl) ★ Coloured sticky tape. Check that there are no items of steel or iron within reach.

Directions

1. Fill the bowl with water and place on the surface of the water a polystyrene tray with the magnet taped at the centre.

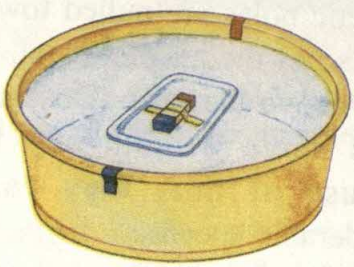


2. Twirl the tray around. Wait until it stops.



3. Put two piece of sticky tape in the edge of the bowl according to the two poles of the magnet.

4. Now twirl the tray once again.

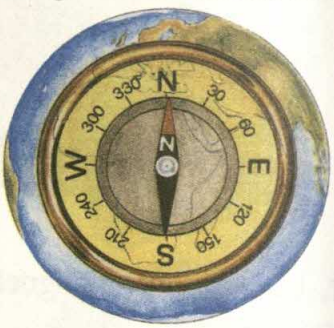


Result

When the tray stops, the poles of the magnet match the two marks once again.

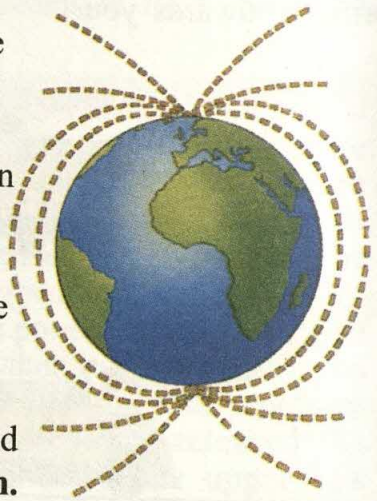
Reason

Because the magnetic force exerted by the Earth is so strong that it makes all movable magnets point one of their poles towards the north pole, the other towards the south pole.



EARTH'S MAGNETISM

The Earth produces a magnetic field which makes it seem as though it has a huge *bar* magnet inside it. Electric currents flowing within the Earth's liquid iron core cause the Earth's magnetism, which is called **geomagnetism.**



MAGNETIC FORCE

CAN SOMETHING BE MADE MAGNETIC ?

An object made of iron or steel can be magnetized by stroking it with the end of a magnet.

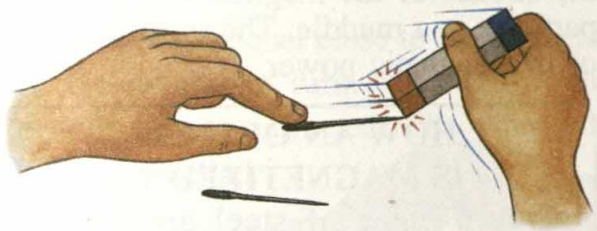
TRY IT YOURSELF

Things you will need

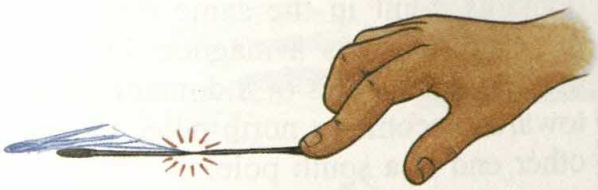
- ★ A bar magnet
- ★ Two large needles

Directions

1. Using the end of the magnet, stroke each needle along its entire length 40 times, each time in the same direction.



2. Push one needle close to the other, first pushing with the point, then with the eye of the needle.

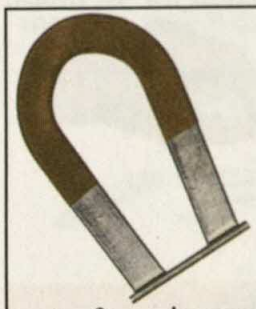


Result

The needle either attract or repel, according to the end which you push forward.

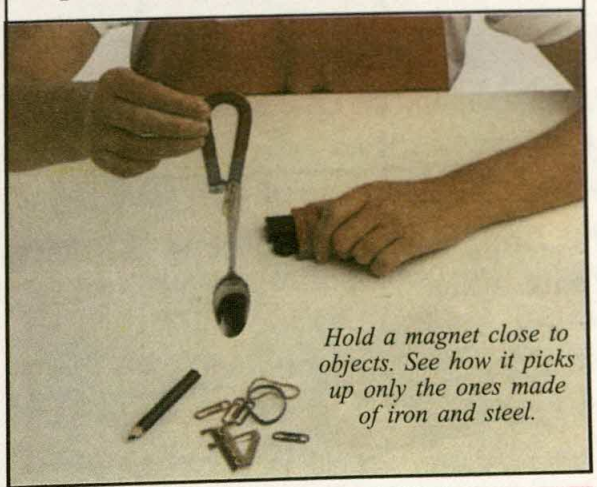
Reason

Because the rubbing of the magnet on the needles has created a permanent magnetization. The needles are, in fact, acting like two magnets and they attract or repel according to the poles which you bring closer.



MAN-MADE MAGNET

People have not only learned to use natural magnets, but also to make artificial magnets from iron or other special metals. The materials used to make artificial magnets are subjected to heat and then left to cool in moulds in the presence of a strong magnetic field. Once cooled and hardened, the material will have acquired magnetic properties.



Hold a magnet close to objects. See how it picks up only the ones made of iron and steel.

MAGNETIC FORCE

CAN A MAGNET LOSE ITS FORCE ?

When magnets are dropped or subjected to knocks, they can become de-magnetized.

TRY IT YOURSELF

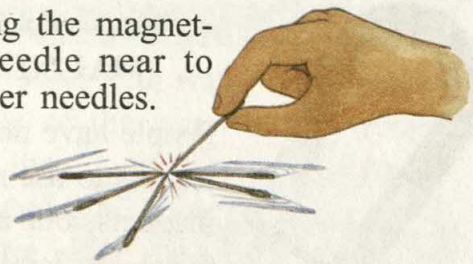
Things you will need

★ Some needles ★ A magnet ★ A hard surface

Directions

1. Stroke the needle along its entire length using one end of the magnet. Stroke in the same direction for 40 times.

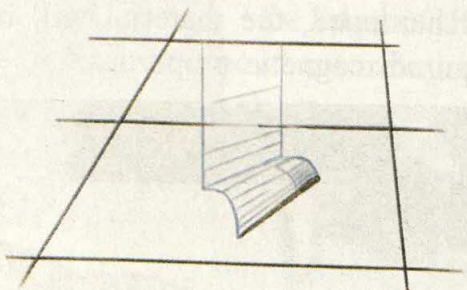
2. Bring the magnetized needle near to the other needles.



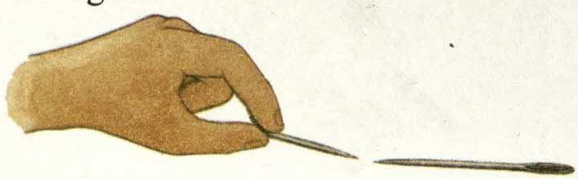
Result

As in the last experiment, the magnetized needle attracts the others.

3. Now let the magnetized needle drop repeatedly on the hard surface.



4. Bring this needle close to the others once again.



Result

The magnetized needle no longer attracts the others.

Reason

Because the needle has lost its magnetic force as a result of being dropped on the hard surface. With each drop, the particles which comprise the needle are shaken around in the opposite direction to the strokes of the magnet. This puts the particles in a muddle. The result is a loss of the magnetic power.

HOW AN OBJECT IS MAGNETIZED ?

Inside a piece of steel are a large numbers of tiny magnetized regions called domains. These are usually jumbled up, so their effects cancel out, and the steel is not magnetized. If the domains point in the same direction, the steel becomes a magnet. The end that the north poles of a domains point towards becomes a north pole, and the other end is a south pole.

In unmagnetized steel, the magnetic domains are jumbled. Their north and south poles cancel each other out.

Stroking steel with a bar magnet magnetizes the steel. The magnet pulls the domains in the same direciton.

Striking a magnet with a hammer shakes up the domains. Their like poles push apart and the steel loses its magnetism.

MAGNETIC FORCE

CAN A MAGNET HAVE ONLY ONE POLE ?

In magnets, the negative and positive charges are always at the two opposite ends.

TRY IT YOURSELF

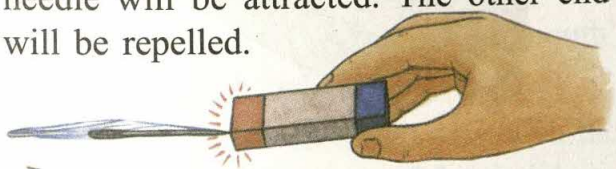
Things you will need

- A big needle
- A bar magnet
- Pliers
- Pins

Directions

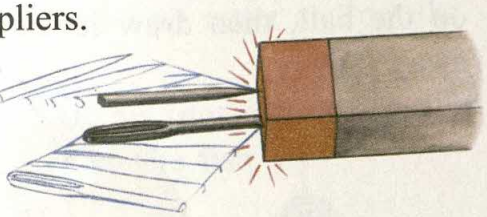
1. Magnetize the needle, as explained in the last few experiments.

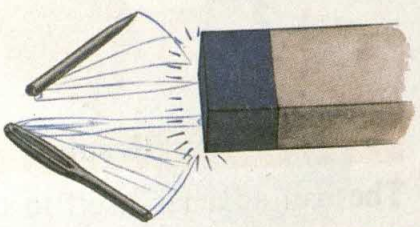
2. Bring the magnet close to the two ends of the needle in turn. One end of the needle will be attracted. The other end will be repelled.



3. Ask an adult to break a needle in half with the pliers.

4. Try again to bring the magnet near to the two pieces of the needle.





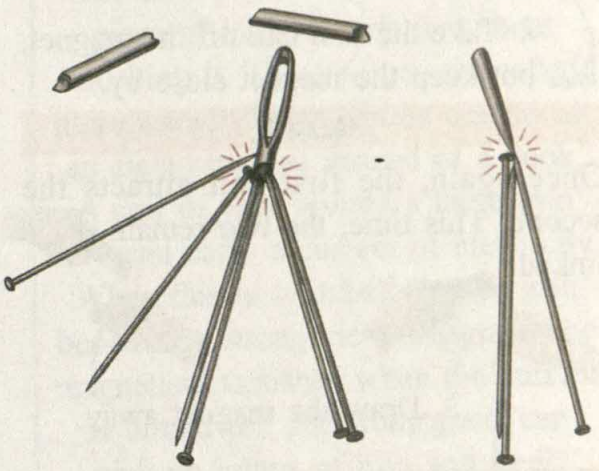
Result

The two parts of the needle both act like small magnets, each with a north and a south pole.

5. Divide each piece of the needle in half once again. Bring the magnet close to each piece, and the pins.

Result

All the pieces of the needle are attracted or repelled by the two poles of the magnet and they are able to magnetize the pins. So the pieces of the needle are now small magnets, each with two poles.



Reason

Magnets are made up of countless tiny, little magnets called magnetic elements, each one with a positive pole and a negative pole. Also, if we divide the magnet into tiny, little pieces, each piece will still keep two distinct poles. From this experiment, you will see that magnetism is present in each atom (the tiniest part) of a magnet.

CAN MAGNETISM BE TRANSMITTED ?

Magnetism can be transmitted temporarily by contact or by induction.

TRY IT YOURSELF

Things you will need

★ A magnet ★ Two nails

Directions

1. Pick up one nail with the magnet. Then draw this nail towards the second one.

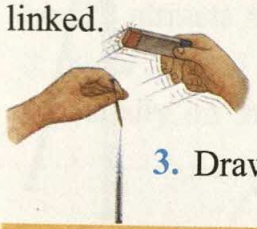
Result

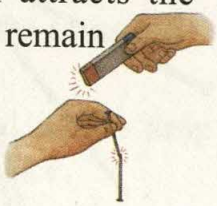
The first nail attracts the second one.

2. Take the first nail off the magnet, but keep the magnet close by.

Result

Once again, the first nail attracts the second. This time, the two remain linked.





3. Draw the magnet away.

Result

The two nails separate and the second one falls.

Reason

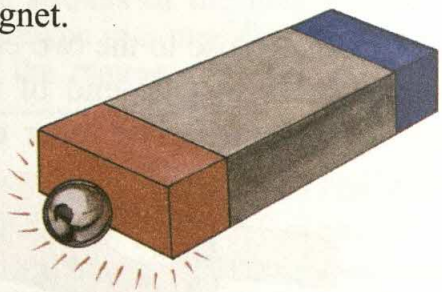
Because on contact with the magnet, the first nail is magnetized and works like a magnet on the second nail. The magnetic force of the magnet is also exerted nearby, and so this force is transmitted to the two nails in both parts of the experiment. This transmission is then broken by the magnet being drawn away.

Things you will need

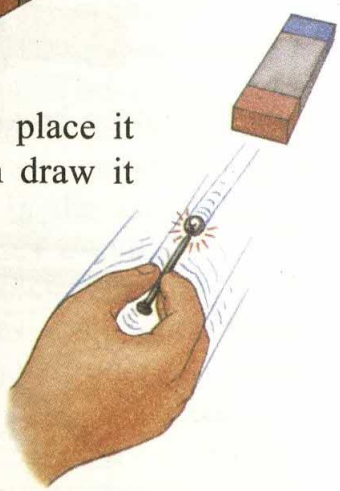
★ A nail ★ A bar magnet ★ A steel ball (like the ones found inside a ball-bearing)

Directions

1. Bring the magnet close to the steel ball. Touch the ball with your finger to test the force by which it is drawn to the magnet.



2. Take the nail, place it on the ball, then draw it away.



Result

The ball attaches itself to the nail.

Reason

Because the magnetic force of the magnet passes through the nail, giving it the same magnetic force.

MAGNETIC FORCE

CAN MAGNETIC FORCE HINDER GRAVITY ?

The force of magnetism can overcome the force of gravity.

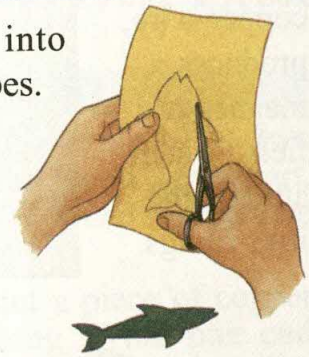
TRY IT YOURSELF

Things you will need

★ Scraps of coloured plastic ★ Paper-clips ★ A little stick ★ Thread ★ A horse-shoe magnet ★ A little bowl ★ Water ★ Scissors

Directions

1. Cut the plastic into some little fish shapes.

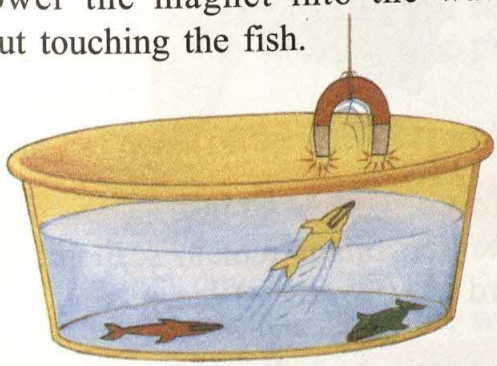


2. Put a paper-clip at the 'mouth' of each fish.

3. Tie the magnet on to the stick with the string. This will be your fishing rod.

4. Fill the bowl with water and put the fish in it.

5. Lower the magnet into the water without touching the fish.



Result

The fish rise up towards the magnet, as if they are swallowing the bait !

Reason

The magnet exerts a force greater than the gravity which pulls the fish towards the bottom of the bowl.

CONTACT AND NON-CONTACT FORCES

Some forces are only produced when one object touches another. These are called contact forces. Other forces do not need contact to have an effect. For example, a magnet can pull a piece of iron towards it without touching it. These forces are called **non-contact forces**. Some cranes use an electromagnet instead of a hook. A coil of wire around a large iron core can carry a current of electricity. When this is switched on, the iron becomes a strong electromagnet. The magnetism vanishes when the current is turned off. Electromagnets can pick up lumps of iron and steel.

MAGNETISM AND ELECTRICITY

IS MAGNETIC FORCE PRODUCED ONLY BY MAGNETS ?

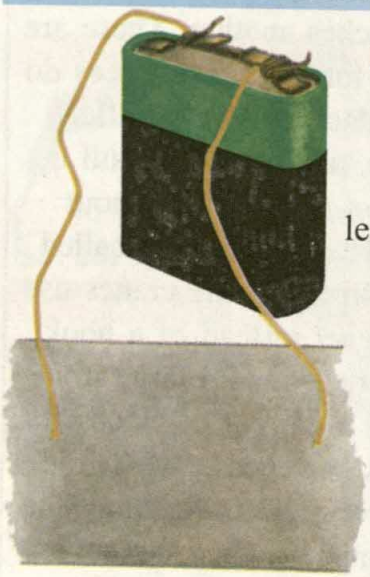
Electrical current can also generate a magnetic field.

TRY IT YOURSELF

Things you will need

- ★ A 4.5 volt battery
- ★ Copper wire
- ★ A piece of card
- ★ Scissors
- ★ Iron filings

Directions



1. Ask an adult to make two holes in the cardboard at least 10cm apart.

2. Ask an adult to cut a piece of copper wire about 30cm long. Thread this through the holes in the card. Then wind the ends around the battery contacts.

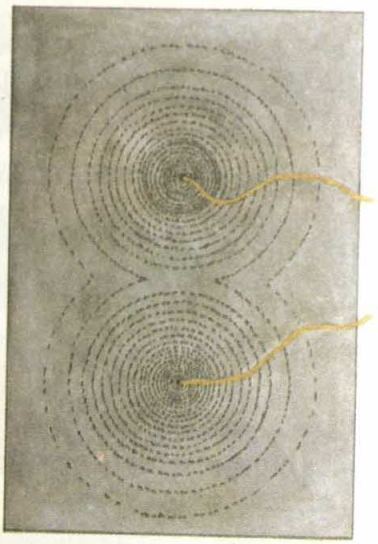
3. Sprinkle the card with iron filings.

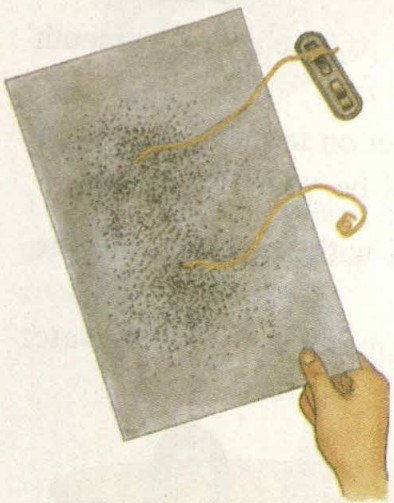
Result

The iron filings arrange themselves around the copper wire in concentric circles.

Reason

Because the current of electricity generated by the battery and which passes through the copper wire, produces a magnetic field, which attracts the iron filings.





4. Detach one end of the wire from a battery contact.

5. Move the card to displace the iron filings.

Result

The iron filings remain scattered on the card in a haphazard way.

Reason

The magnetic field generated by the electricity is broken when the flow of electric current is interrupted.

MAGNETISM AND ELECTRICITY

HOW IS AN ELECTROMAGNET MADE ?

An electromagnet is a metal object which acquires magnetic properties by the passage of a current of electricity.

TRY IT YOURSELF

Things you will need

★ A 4.5 volt battery ★ A little piece of wood ★ Two metal drawing pins ★ A metal paper-clip ★ Copper wire ★ A large iron nail ★ Sticky tape ★ A box of pins ★ Scissors

Directions

1. First, make a switch. Push the two drawing pins into the wood 2cm apart. Open up the paper-clip and thread one end under the wire.

2. Ask an adult to cut a piece of copper wire about 15cm long. Wind one end around the battery contact. Fix the other end under the drawing pin on the switch.

3. Cut another piece of copper wire about 60-70cm long. Wind the centre of the wire around the nail, about 10 times.

4. Wind one end of the same wire to the other battery contact. Slip the other end under the second drawing pin.

5. Turn on the switch by making a connection between the two drawing pins with the paper-clip.

6. Bring the point of the nail near to the pins in the box.

Result

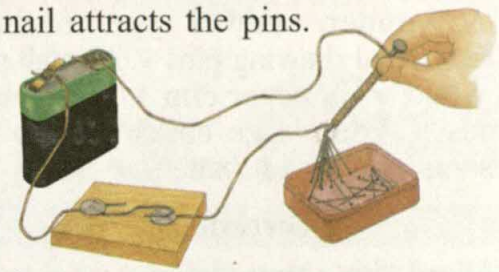
The pins are not drawn by the nail.

7. Disconnect the switch. Wrap the wire around the nail as many times as possible and as tightly and as close as you can. (It may help to keep the wire firm with sticky tape.) Reconnect the wire to the battery and to the switch.

8. Turn on the switch. Try to attract the pins once again with the point of the nail.

Result

The nail attracts the pins.



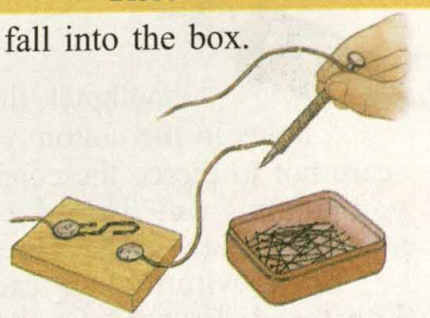
Reason

Because the more wire which is around the nail, the greater the intensity of the magnetic field which is generated. The nail is now just like a proper magnet.

9. Turn off the switch by moving the paper-clip.

Result

The pins fall into the box.



Reason

Because when the flow of electricity generated by the battery is interrupted, the magnetic field goes, and the iron nail is de magnetized. But if the nail were made of steel, its magnetic power would remain, even in the absence of an electric current.

MAGNETISM AND ELECTRICITY

CAN ELECTROMAGNETIC FORCE POWER A MOTOR ?

Electrical motors work due to the combination of electricity and magnetism.

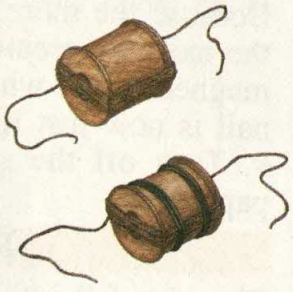
TRY IT YOURSELF

Things you will need

★ Two bar magnets with marked poles ★ A cotton reel ★ A few metres of copper wire ★ Three pieces of electric cable ★ A wooden skewer-type toothpick ★ Two metal drawing pins ★ A small piece of wood ★ A paper-clip ★ Two elastic bands ★ Four large corks ★ Two iron washers ★ A 9 volt battery ★ Sticky tape

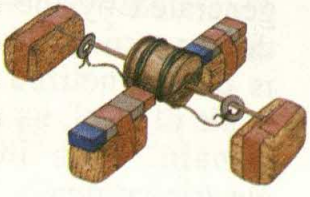
Directions

1. Wind the copper wire a number of times around the cotton reel from the bottom to the top. Wind as tight and as closely as you can, leaving the two ends of the wire free. Keep the wire around the reel with elastic bands.

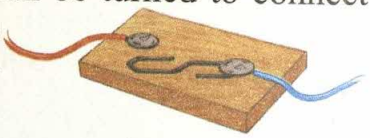


2. Thread the toothpick through the holes in the cotton reel, taking care not to pierce the copper wire if you possibly can. Thread a washer at either end of the stick. Thread an end of the wire through each washer.

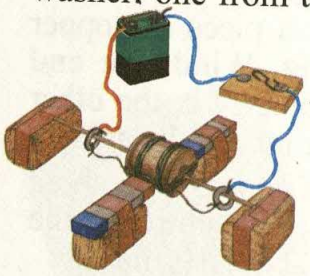
3. With the sticky tape, fix the magnets to two corks and place them with the opposite poles facing each other. Place the other two corks crossways between the two magnets. Put the stick on top of these corks and fasten down with sticky tape.



4. Stick the two drawing pins in the wood about 2cm apart. Open up the paper-clip, and thread one end under the drawing pin so that the clip can be turned to connect up with both pins. This will be your switch.



5. Peel off a little of the plastic covering from the ends of the three pieces of electric cable. Then make this circuit: one wire between a battery contact and the washer; one from the other washer to the drawing pin on the wood; and one from the other drawing pin to the second battery contact.



6. Turn on the switch by putting the paper-clip on the drawing pin (so that the current of electricity can flow through).

Result

The cotton reel moves jerkily.

Reason

The two magnets generate a magnetic field which comes from the positive pole of one magnet to the negative pole of the other. When we activate the flow on an electric current, a second magnetic field is created around the copper wire. The two fields alternately attract and repel, making movements of winding the wire on the reel towards the top and then towards the bottom.

MAGNETISM AND ELECTRICITY

HAS AN ELECTROMAGNET TWO POLES, LIKE AN ORDINARY MAGNET ?

The electromagnet has two poles, but these are not fixed. They change according to the direction of the electrical current.

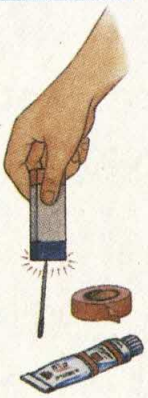
TRY IT YOURSELF

Things you will need

★ A large iron nail ★ A bar magnet with two poles marked ★ A 4.5 volt battery ★ Copper wire ★ A needle ★ A piece of cork ★ Sticky tape ★ A bowl ★ Water ★ Coloured paint

Directions

1. Magnetize the needle by stroking it 40 times along its length in the same direction with the end of the magnet. Watch the attraction between the needle and the magnet, especially at the north pole of the needle. Paint the north pole of the needle red.



2. Fix the needle to the cork with the sticky tape. Fill the bowl with water. Place the cork on the surface of the water.

3. Make an electromagnet as explained in the last experiment. Wind the middle of copper wire around the nail then connect the ends of the wire to the battery contacts.

4. Draw the nail towards one end of the needle, and then the other end.

Result

One end of the needle becomes attracted by the nail. This is the coloured tip. From this, we know that the point of the needle is the south pole and the eye is the north pole.

5. Detach the copper wire of the electromagnet and from the battery contacts. Then reattach each end on the opposite battery contact.

6. Bring the point of the nail near to the end of the needle. At first, the needle will be attracted.

Result

The needle begins to spin.

Reason

Because in an electromagnet, the magnetic field is positive or negative, according to the direction in which the current flows. When you changed over the position of the wires, you changed the direction of the electrical flow. As a result of this, you also changed the polarity of the nail.

WATER

Water is the most common substance on earth. 70% of the world's surface is covered by water. Water is also the most important substance on earth. Without it life would be impossible. Life first started in water, and the bodies of all living things are mostly water.

There is no such thing as 'pure' water. Water contains MINERALS, which it has picked up from the surrounding earth and rocks.

Water exists in three forms. At 0°C it breezes into solid ice. At 100°C it boils into steam. Normal air takes up water easily, and CLOUDS are huge collections of water vapour. At any time, clouds contains millions of tonnes of water, which falls back to earth as RAIN. Some of this water stays in the soil or underground for years, but most of it returns to the oceans.

Find the answers about *"The force of water, The surface tension of water, To fleat or not to fleat? The transformation of water, water solutions and many other questions"* by doing experiments in the next pages.

THE FORCE OF WATER

HOW CAN WATER MOVE ?

Water not only moves downwards, it can also rise up by means of capillary action.

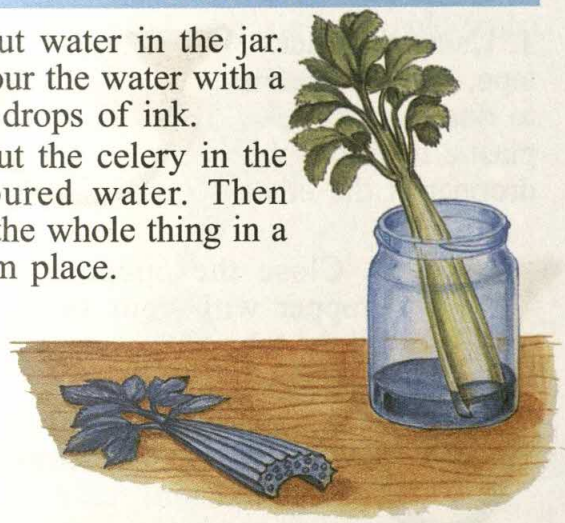
TRY IT YOURSELF

Things you will need

★ A stick of celery complete with leaves, about 20cm long ★ A glass jar ★ Water ★ Blue or red ink

Directions

1. Put water in the jar. Colour the water with a few drops of ink.
2. Put the celery in the coloured water. Then put the whole thing in a warm place.



Result

After a few hours the stick of celery and its leaves take on the same colour as the ink.

Reason

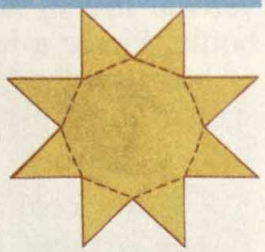
Because if you cut the celery, you will see that the ribs are like little tubes. The water has risen up through these narrow tubes and into the leaves, as if drawn towards the top. This is called capillary action. This is how plants absorb water from the ground through their roots, with the water rising up until it reaches the ends of its leaves. White flowers can sometimes be coloured in the same way.

Things you will need

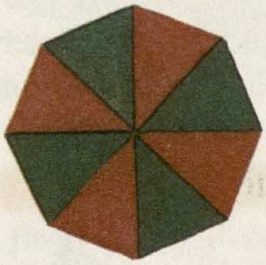
★ A sheet of paper ★ Coloured pencils ★ Scissors ★ A soup plate with some water in it

Directions

1. Draw the shape as you see in the picture. Colour it in, then cut out.



2. Fold the 'petals' inwards along the dotted lines, as shown.



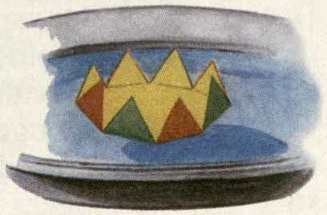
3. Place the paper flower on the water very carefully.

Result

Slowly, the flower opens.

Reason

Because the water penetrates by capillary action into the little empty spaces between the fibres of the paper. This makes the fibres swell, including those along the folds. This swelling makes the lines unfold, and so the flower opens out.



THE FORCE OF WATER

CAN YOU INCREASE THE FORCE OF WATER ?

Water subjected to the pressure of other water or air adds to the strength of its force.

TRY IT YOURSELF

Things you will need

★ Two plastic bottles ★ One nail ★ Sticky tape ★ Water

Directions

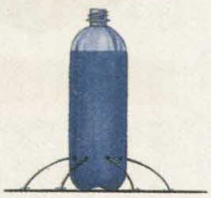
1. Using the nail, pierce a vertical line of holes on one bottle. Pierce a horizontal line of holes on the other bottle, as shown in the picture.

2. Cover both bottles with a sticky tape.

3. Fill the bottles with water. Remove the tape first from one bottle, then the other.

Result

Water spurts out at an equal distance all around the bottle with holes in a horizontal line. But, from the bottle with the holes in a vertical line, water spurts out at different distances. The nearer the base of the bottle, the greater the distance.



Reason

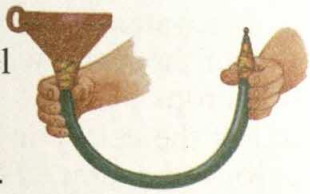
Because the water weighs heavily against the inside of the bottles, and so it escapes through the holes with considerable force. This force is stronger in the bottle (or where the water is deepest) and so the spurt here is longer.

Things you will need

★ A plastic tube ★ Sticky tape ★ The glass (or plastic) part of an 'eye-dropper' ★ A funnel ★ Water

Directions

1. Using the sticky tape, bind the funnel to one end of the plastic tube and the dropper at the other.



2. Close the opening of the dropper with your finger and fill the tube with water through the funnel.

3. Lower the end with the dropper and take away your finger.

Result

A spurt of water escapes from the dropper. The higher the funnel, the higher the spurt of water.

Reason

Because the force of pressure exerted by the air on the opening of the funnel is greater than the weight of the water inside the tube, and this produces an upward jet. Raising the funnel makes the spurt of water higher, because the water in the tube is falling from a greater height. Raising an object's height above the Earth's surface gives that object additional potential energy.

THE PRESSURE OF AIR

WHY DOES HEAT MAKE WATER MOVE ABOUT ?

When heat spreads in water, it becomes light and will rise up in cold water.

TRY IT YOURSELF

Things you will need

- ★ A see-through bowl or basin
- ★ A little glass jar with a lid coloured ink
- ★ Water

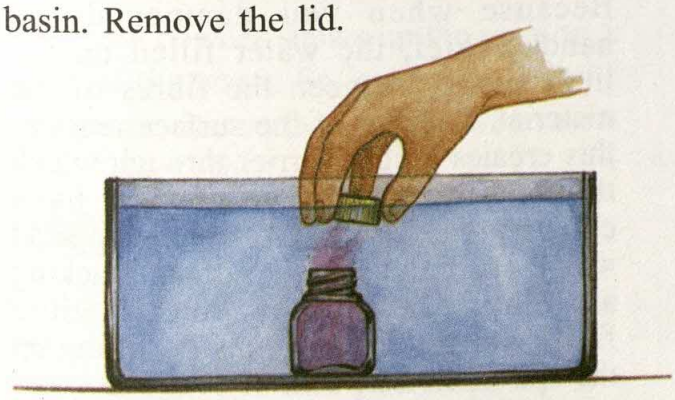
Directions

1. Fill the bowl or basin with cold water.

2. Put a few drops of ink in the jar and fill with hot (not boiling) water.

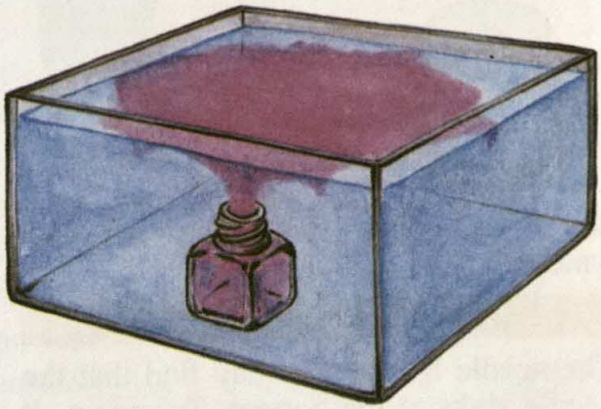
(Ask an adult to do this for you.) Then put the lid on.

3. Immerse the jar in the cold water and put it on the bottom of the bowl or basin. Remove the lid.



Result

The coloured water escapes into the bowl or basin and rises up, spreading out towards the surface. After a few moments it begins to descend and to mix with the rest of the water.



Reason

Because like all matter, water is made up of tiny, moving particles called molecules. Heat speeds up the movement of the molecules, and they move away from each other. As they spread out, they become less dense (less tightly packed together) and so lighter. That is why the coloured hot water 'floats' on the cold water. As the heat spreads and the coloured water begins to reach the same temperature as the cold, so it descends and begins to mix with the rest of the water.

THE SURFACE TENSION OF AIR

WHY ARE DROPS OF WATER ROUND ?

The surface tension of the water creates a membrane which can contain a small quantity in a little, round drop.

TRY IT YOURSELF

Things you will need

★ Tweezers ★ A needle ★ A glass
★ Water

Directions

1. Fill the glass with water up to the brim.

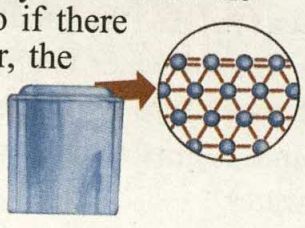
2. Take the needle with the tweezers and let it down very gently on the surface of the water.

Result

The needle floats (you may find that the needle sinks to the bottom. Try again. It is very important to place it slowly and horizontally?

Reason

The molecules of water on the surface form a sort of film which is able to support a light object. This force which keeps the molecules together is called surface tension. When you fill the glass to the brim, look closely at the surface of the water. Above the brim, it bends slightly pulling tightly to contain the water like a bag. So if there is only a little water, the surface tension will make it form into a round drop.



Things you will need

★ A handkerchief ★ An elastic band
★ A glass ★ Water

Directions

1. Put the handkerchief in water. Then wring it out.

2. Fill the glass with water.

3. Place the handkerchief over the glass. Stretch tightly and keep in place with the elastic band.

4. Quickly turn the glass upside down (Work over a sink).

Result

The water remains blocked in the glass, as if the handkerchief were waterproof.

Reason

Because when you dampened the handkerchief, the water filled up the little spaces between the fibres of the material. Because of the surface tension, this creates a tight barrier through which the water cannot penetrate. Wet hairs clinging together in locks and damp sand which can be modelled without cracking are other examples of water binding fibres and particles together by filling up the spaces in between.

THE SURFACE TENSION OF WATER

HOW DOES SOAP ACT IN WATER ?

Soap diminishes the force which keeps the water molecules together.

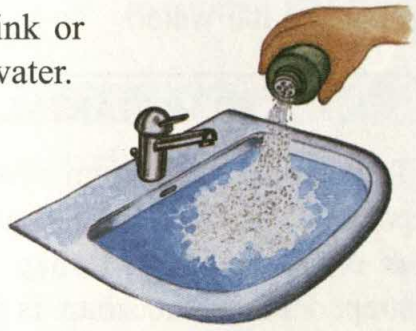
TRY IT YOURSELF

Things you will need

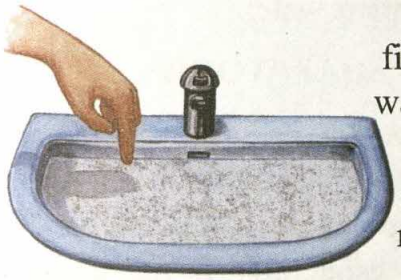
★ Talcum powder ★ Water ★ Liquid soap ★ A sink or a bowl

Directions

1. Fill the sink or basin with water.



2. Sprinkle the talcum powder on the surface of the water.



3. Dip your finger into the water here and there, as if you were making holes in it.

Result

The talcum powder shows up the surface tension of the water. So, as soon as your finger pierces the surface tension, you can see the 'hole' closing again.

Reason

Because the surface tension is a strong force. It is broken only momentarily when you pierce it with your finger.

4. Now put a drop of liquid soap on your finger. (Take care : do this away from the sink to avoid soap getting into the water). Then put the soapy finger into the water, close to the edge of the sink.

5. Make holes in the talcum-powdered water with the soapy finger.

Result

The first time you dip in your soapy finger, the talcum powder moves away. But the next time you dip it into the talcum powder surface, your finger leaves 'holes'.

Reason

Because the soap loosens the tension at the place where you dip your finger. On the rest of the surface, the tension is stronger and so this attracts and holds back the talcum powder. The holes left by the soapy finger do not close again, because in these places they are together again. So the 'surface skin' cannot regain its unbroken state. If you want to repeat the experiment, you will need to change the water.

THE SURFACE TENSION OF WATER

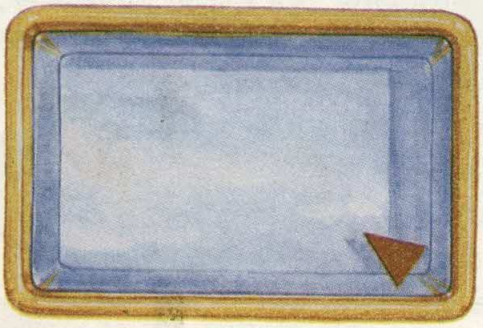
Things you will need

- ★ A basin or a sink
- ★ A piece of card
- ★ Scissors
- ★ Liquid soap
- ★ Water

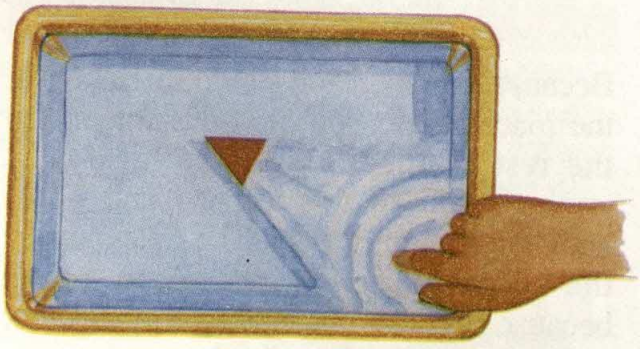
Directions

1. Fill the basin or sink with water.

2. Cut a triangle shape from the card. When the water is still, place the cardboard triangle in a corner of the basin or sink, pointing towards the centre.



3. Put a little soap on the tip of one finger. (Do this away from the sink). Then put the soapy finger in the water, behind your cardboard 'boat.'



Result

The boat shoots forward towards the opposite side of the basin or sink.

Reason

Because at the beginning of the experiment, the boat stayed still because the surface tension was pulling it in all directions. The soap lessens the tension behind the boat. This means that the boat is pulled in front, into the area where the surface tension is still strong. If you want to repeat the experiment, you will have to change the water.

SOAP MAKING

To make soaps, sodium hydroxide and potassium hydroxide are boiled with fat or oil to make hard soap and liquid soap. Before the soap is made into blocks, flakes, or powders, chemicals are added to kill germs, add colour and scent, and soften water.

HOW SOAP WORKS ?

Imagine how dirty you would be without soap. Water alone is not able to remove the dirt from clothes, plates or the skin, especially if the dirt is greasy. There are two main types of molecules in detergents—those which attract and cling on to the small particles of dirt and those which dissolve in the water, stopping the water molecules from coming together. This is how the detergent breaks up the dirt and removes it from the object being washed. Then it spreads the dirt out into the water, ready to be drained away.

THE SURFACE TENSION OF WATER

HOW ARE SOAP BUBBLES MADE ?

Soap reduces the surface tension of water, thus allowing the air inside to expand.

TRY IT YOURSELF

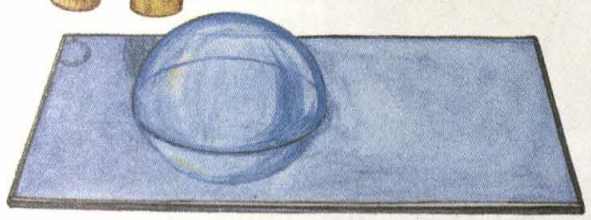
Things you will need

★ Liquid for soap bubbles (it is best if you keep this in the refrigerator for about an hour) ★ A drinking straw ★ A smooth surface to work on (something like glass, plastic or steel)

Directions

1. Moisten the work surface.

2. Dip the straw in the soap. Blow a bubble and slowly place this on the surface: the bubble will become a dome.



3. Dip the straw in the soap again, and also wet the outside with the soap. Insert the straw very carefully into the first dome and blow gently to form a second dome.

4. Make a third dome in the same way. (Work very carefully, so that each new dome does not touch the one which you made before).

Result

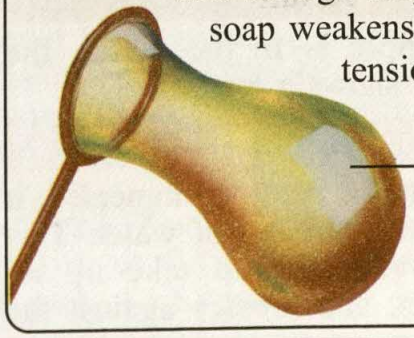
Each bubble positions itself at the centre of the dome made before, and it makes the others grow bigger.

Reason

Because there is air inside the bubble. The introduction of a new bubble moves the air from the one before, which grows larger because of the elasticity provided by the soap. The more you try this experiment, the more different structures you will find you can create by placing the bubbles on the surface and seeing how much your bubble mix can expand.

ARE STRANGE SHAPES BUBBLE POSSIBLE ?

A liquid behaves as if its surface was covered by an invisible stretched skin. This effect is called surface tension. It is caused by forces between molecules pulling those molecules at the surface inwards. A bubble is normally a sphere because surface tension pulls it into this shape. Soapy bubbles can be stretched into strange shapes because soap weakens the surface tension of water.



Soapy bubble

TO FLOAT OR NOT TO FLOAT

WHY DO THINGS SEEM TO WEIGH LESS IN WATER ?

Objects in water get an upward thrust which is equal to the weight of the water displaced by the object.

TRY IT YOURSELF

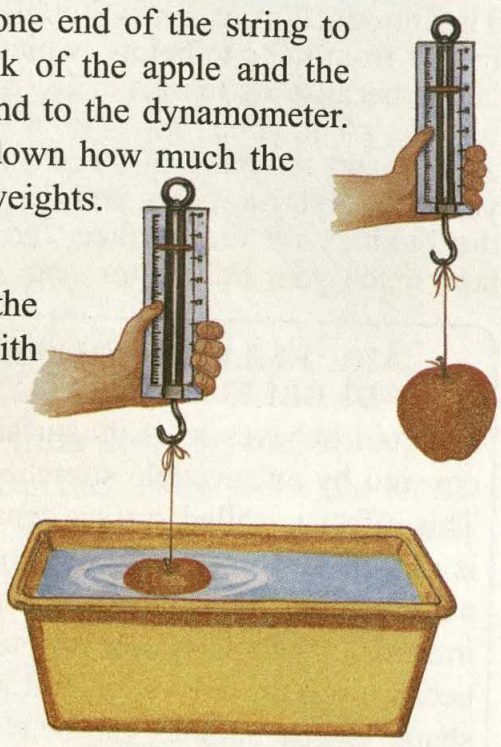
Things you will need

★ A dynamometer (an instrument for measuring force) ★ An apple ★ Thin string ★ A deep bow ★ Water ★ Pen and paper

Directions

1. Tie one end of the string to the stalk of the apple and the other end to the dynamometer. Write down how much the apple weights.

2. Fill the bowl with water.

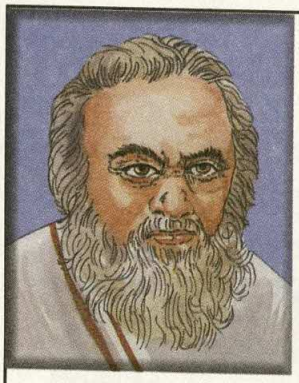


Result

When the apple is in the water, the dynamometer shows a lower weight.

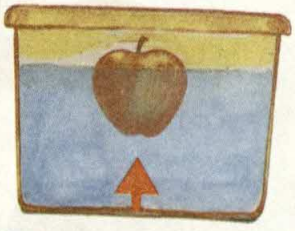
Reason

Because when the apple is immersed, it moves a certain amount of water. This water it moves tries to take up its position again, and presses against the apple, pushing it up towards the top. This push is called displacement and is the same as the weight of the water which the apple has moved. So if an object weighing 500g is immersed and moves 200g of water, it gets a push towards the top which diminishes its weight by 200g. Therefore, when immersed, that object will show a weight of 300g.



THE ARCHIMEDES' PRINCIPLE

Have you noticed that when you get into the bath, the level of the water rises ? This simple fact is said to be the inspiration for the Greek inventor who lived in the third century A.D. After noting the rising of his bath-water, he carried out many experiments, not only with water but also with other liquids to prove his theory of the displacement of water and establish the Archimedes' Principle. This Rule states that an object immersed in liquid is given an upward thrust, which is equal to the weight of the liquid which the object has moved.



An apple floats in water because the weight of water it displaces is equal to its own weight. This means that the force of the upthrust exactly equals the force of the apple's weight pushing down.

TO FLOAT OR NOT TO FLOAT

WHY DO SOME THINGS FLOAT AND OTHERS NOT ?

The floating of an object depends on its shape and its density.

TRY IT YOURSELF

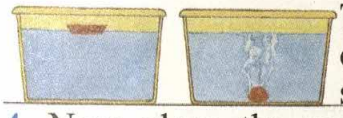
Things you will need

★ Modelling clay ★ A saucepan with a lid ★ A bowl ★ Water

Directions

1. Fill the bowl with water.
2. Mould the modelling clay into a flat shape and place it on the water.
3. Now roll the boat-shaped clay into a ball. Place this on the water.

Result



The little boat settles on top. The ball sinks to the bottom.

4. Now place the saucepan lid on the water, first horizontally, then vertically.

Result

When horizontal, the saucepan lid floats. When it is vertical, it sinks to the bottom.

Reason

Because the more water which is displaced by an object, the greater the thrust which the object gets towards the top. With the clay boat and the horizontal saucepan lid, a wide surface floats on the water, and therefore they each displace a lot which is sufficient to keep them afloat. The clay ball and the vertical saucepan lid displaces only a little water, therefore the area which is immersed is reduced. So the thrust which they get is not enough to keep them afloat. This experiment shows that floating also depends on the shape of an object.

Things you will need

★ Plasticine ★ Small objects, such as paper-clips, marbles, dice, pebbles ★ A basin ★ Water

Directions

1. Mould the plasticine into a little tub, as you see in the picture.
2. Fill the basin with water and place the tub in the water. Make a notch on the tub to mark the level of the water.
3. Very slowly, put the objects in the tub and see if the notch becomes lower than the level of water.

Result

The more the tub is filled, the lower it sinks into the water.

Reason

Because the tub is concave, which means it bends inward, and it contains air. When it becomes filled with objects, but keeps its same size, the tub weighs more, which means it has a greater density (density means the weight contained within a volume of space). As long as the displaced water is the same weight, which is more that the tub, it keeps afloat, even if it continues to sink down still more. When the weight of the tub is more than that of the water which it has displaced, the tub will sink. This experiment shows that the ability to float also depends on the density of whatever is put into the water.

TO FLOAT OR NOT TO FLOAT

DOES GAS AND LIQUID FLOAT IN WATER ?

All substances which have a lesser density than water will float on it.

TRY IT YOURSELF

Things you will need

★ Mothballs ★ Vinegar ★ Bicarbonate of soda ★ Water ★ A glass jar ★ A spoon

Directions

1. Fill the jar with water, then add two spoons of vinegar and two of bicarbonate of soda. Mix thoroughly.

2. Put the mothballs in the water. (If they feel very smooth, scratch them a little to make them rough).

Result

At first, the balls go to the bottom. But after a short time, little bubbles attach themselves to the surface of the balls and they begin to rise, then descend and rise up a few times.

Reason

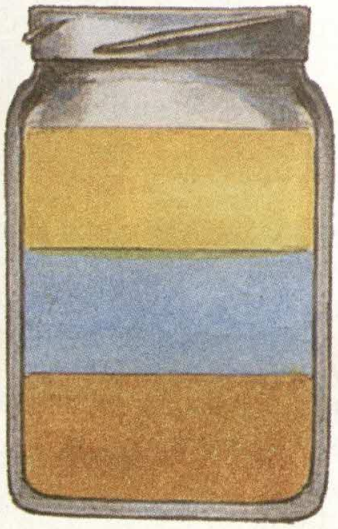
Because the vinegar and bicarbonate of soda, mixed together, produce a gas, carbon dioxide. This is released into the water in the form of little bubbles. Like all gases, carbon dioxide is lighter than water and so it floats. When the carbon dioxide attaches itself to the mothballs, it takes them with it as it rises to the top, where it disperses into the air. At this point, the mothballs become heavy again and go to the bottom, then rise up, carried along by other bubbles of carbon dioxide.

Things you will need

★ A see-through container
★ Liquid honey
★ Linseed or corn oil
★ Water

Directions

1. Pour the honey and then the oil into the jar.



2. Pour in the water.

Result

The liquids do not mix, but separate into layers. The oil floats on the honey; the water sinks underneath the oil, but floats on the honey.

Reason

Because the three liquids have different densities. The oil, which has the least density, floats on the water. But the honey settles on the bottom because it has the greatest density.

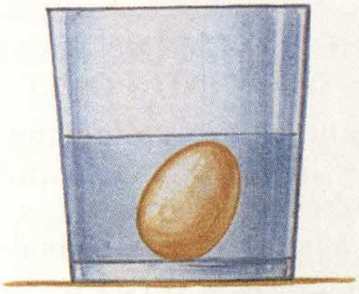
TO FLOAT OR NOT TO FLOAT

Things you will need

- Table salt
- A large glass
- An egg
- A teaspoon
- A dessertspoon
- Water

Directions

1. Half fill the glass with water. Then, using the dessertspoon, carefully put the egg in the water.

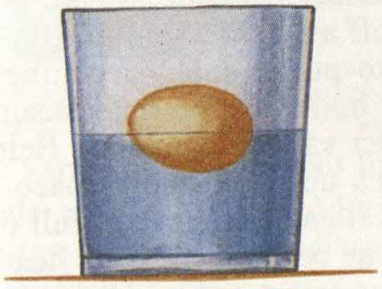


Result

The egg sinks to the bottom of the glass.

2. Take the egg out of the water. Add 10 tablespoons of table salt, and mix until it is dissolved. Now you have made brine.

3. Put the egg in the water once more.

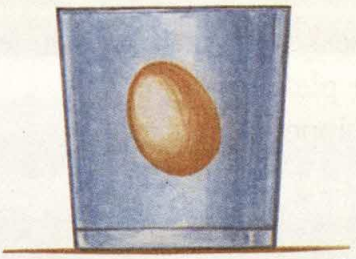


Result

The egg floats.

4. Take the egg out of the water again. Slowly pour more water into the glass until it is full.

5. Put the egg in the water again.



Result

The egg remains suspended in the centre of the glass.

Reason

Because the egg is more dense than the water, and so it sinks. The salt water (the brine) is more dense than clear water, and therefore makes it possible for the egg to float. In the last stage of the experiment, the clear water floats on the brine because clear water has a lesser density. So the egg stays in the middle, because it has more density than the clear water but is less dense than the brine.

There are some toys which use liquids of different densities. Because it is impossible for the two liquids shown here to mix, this produces a fascinating wave effect. In this toy, the boats have a density which is less than the blue liquid, but more than the clear liquid. This is why they remain suspended in the centre.

THE TRANSFORMATION OF WATER

HOW DOES HEAT DRY SOMETHING WHICH IS DAMP ?

Heat makes water evaporate and disperse through the air.

TRY IT YOURSELF

Things you will need

- ★ Two glasses, exactly the same
- ★ A little plate
- ★ A felt-tipped pen
- ★ Water

Directions

1. Fill the two glasses with water to the same level. Mark this level with the felt-tipped pen.

2. Cover one glass with the plate.

3. Put the two glasses near a radiator, or in direct sunlight.

Result

The day after, the level of water in the uncovered glass is lower. The level in the covered jar is almost the same.

Reason

Because of the heat, the water in the uncovered glass has evaporated-transformed into tiny, invisible drops of steam vapour which become absorbed into the air and 'float away'. This is how clothes which are hung up or spread out in the sun become dry. As well as heat, moving air (such as the wind or our breath) makes water evaporate. It moves the steam vapour which comes off wet objects and this make it possible for the air around to absorb it.

BOILING POINT AND MELTING POINT

At a temperature called the boiling point, a liquid changes into a gas. Below the boiling point gas changes back to a liquid again. The boiling point of water is 100^0C (212^0F).

Heating a solid makes it melt into liquid. This happens only at a certain temperature, which is called the melting point. Below this temperature, the liquid freezes to a solid again. The melting point of water is 0^0C (32^0F).

THE STRENGTH OR ENERGY OF STEAM

Steam takes up more space than water kept under pressure, steam is able to give off an enormous strength, which is able to power many machines. When water boils, it turns into steam. Steam is water vapour that is hot. Being a gas, it takes up much more space than the liquid it came from. It is full of energy and can be used to drive heat engines such as steam turbine. It enters the turbine at high temperature and pressure, and drives the turbine wheels round.

THE TRANSFORMATION OF WATER

WHY DOES IT RAIN ?

When water vapour comes in contact with cold air, it condenses and becomes water again. This is how rain begins.

TRY IT YOURSELF

Things you will need

★ A saucepan ★ A steel lid ★ A hot-plate ★ Water

Directions

1. Fill the saucepan with water. Ask an adult to put it on the hot-plate.

2. When the water boils, hold the lid up high in the cloud of steam which rises up from the water.

Result

Drops of water form under the lid.

Reason

Because vapour rises up from the water as it boils and comes into contact with the cold lid. As this happens, the vapour loses heat and immediately returns to the liquid state. This phenomenon is called condensation.

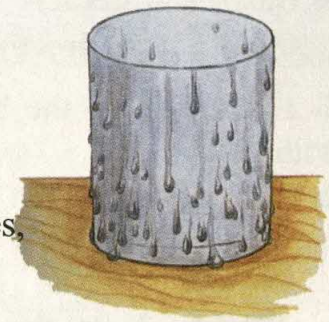
Things you will need

★ A glass ★ A freezer

Directions

1. Make sure the glass is perfectly dry. Put it in the freezer.

2. After 30 minutes, take the glass out.



Result

Immediately, the glass steams up; soon after, tiny droplets of water form on the glass. If you touch it, your finger is damp.

Reason

Because in the freezer, the sides of the glass are very cold. When the glass is brought into contact with the air, the sides of the glass cools the air, and the water vapour in the air changes into tiny drops of water which mist up the glass. In winter, the windows of cars steam up because our breath, rich in water vapour, condenses into drops of water as soon as it comes into contact with cold air.

THE TRANSFORMATION OF WATER

WHY DO WATER PIPES SOMETIMES BURST IN WINTER ?

At 0^0C, water solidifies into ice, and takes up more space than water in its liquid state.

TRY IT YOURSELF

Things you will need

★ A glass or plastic jar with lid
★ Water ★ A freezer

Directions

1. Fill the jar to the brim with water.

2. Place the lid on top of the jar, without screwing it down.

3. Put the whole thing in the freezer and wait until the water in the jar has frozen.

Result

The water has become solid, and has risen above the rim of the jar, raising the lid.

Reason

Because when the water becomes ice, it takes up more space than when it is liquid, and so the jar cannot hold it all. If we were to leave a firmly-closed glass bottle of water in the freezer, we would probably find it in pieces because of the pressure of the ice. The pipes which carry drinking water and water for central heating in the house must be protected in winter and insulated from the cold so that they do not burst because of ice forming inside.

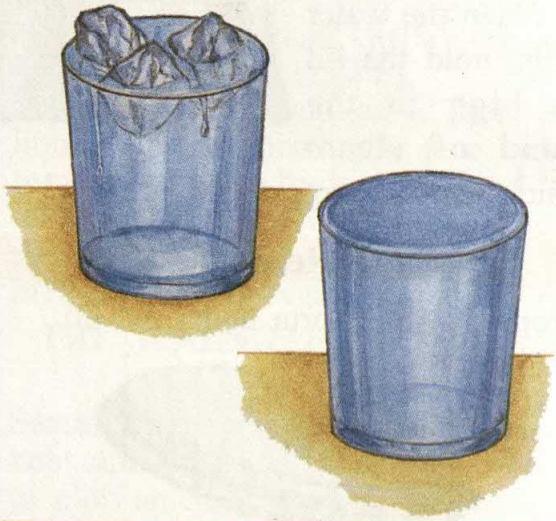
Things you will need

★ A glass
★ Hot water
★ Ice cubes

Directions

1. Fill the glass almost to the brim with hot water.

2. Put one or two ice cubes in the water. Ask some friends if they think the water will overflow when the cubes have melted.



Result

The level of the water remains the same.

Reason

Because water in its liquid state takes up less space than when it is solid. So, when the ice melts, the water does not spill over the rim of the glass.

WATER SOLUTIONS

WHAT HAPPENS TO A SUBSTANCE WHEN IT MELTS IN WATER ?

Substances which are soluble in water dissolve in it.

TRY IT YOURSELF

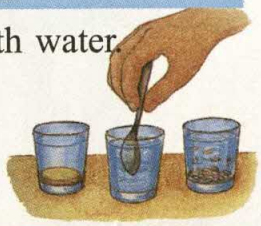
Things you will need

★ 7 little glasses ★ Water ★ A teaspoon ★ Small quantities of salt, sand, sugar, rice, honey, ground coffee and instant coffee

Directions

1. Fill all the glasses with water.

2. Put a teaspoon of one substance in each glass. Mix carefully with the water.

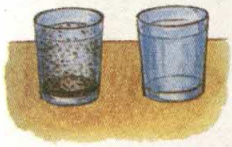


Result

Some substances (sugar, salt, honey and instant coffee) dissolve in the water, colouring it a little. Others (sand, rice and ground coffee) remain visible. They stay suspended in the water during the mixing, then sink to the bottom or float on the water.

Reason

Because with substances which dissolve in water (seeming to disappear as they melt in it), the water molecules are able to slide between the molecules of the substance and separate them. In this way we obtain a solution in which the soluble ('dissolvable') substance does not succeed in settling down to a layer in the water in which it is dissolved (solvent). But if the molecules of the substance are impervious (can withstand) the water, these remain separated and easily visible. In this case we say that the substance is not soluble in water.



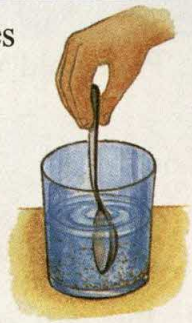
Things you will need

★ Two glasses ★ A teaspoon ★ Cane sugar ★ Hot and cold water

Directions

1. Half fill one of the glasses with cold water.

2. Count how many teaspoons of sugar you can put into the water to dissolve. Stop when sugar remains visible and sinks to the bottom.



3. Half fill the second glass with hot water.

4. Count how many teaspoons of sugar you can manage to dissolve in this glass.

Result

More sugar can be dissolved in the hot water than in the cold water.

Reason

Because when no more sugar can be dissolved in water, we say that the solution is saturated. Due to the heat, the water molecules are still able to absorb more sugar molecules. The solution which is obtained in this way we call supersaturated. When the solution cools down, the excess sugar will be seen at the bottom.

WATER SOLUTIONS

DO SOLUBLE SUBSTANCES EVAPORATE WITH THE WATER ?

With evaporation, water solutions separate. But only pure water evaporates.

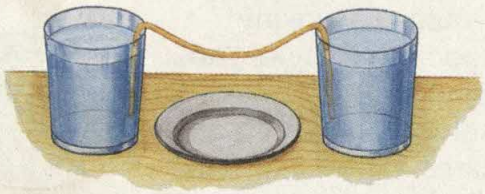
TRY IT YOURSELF

Things you will need

★ Table salt ★ Two glasses ★ A length of cotton ★ A small plate ★ A spoon ★ Water

Directions

1. Pour cold water into the two glasses.



2. Put salt in both glasses, mixing it until you can add no more.
3. Link the two glasses with a thread, so that the two ends dip well into the water. Put the plate under the part of the thread which hangs down between the two glasses.

Result

After a day or so, salt crystals form on the thread and on the plate.

Reason

Because the salt water rose along the thread by capillary action. The water evaporates from the thread (and from the plate where some droplets fall) leaving the salt, which solidifies into crystals this means that the molecules join together to form a particular geometric pattern.

Things you will need

★ Instant coffee ★ A saucepan ★ A spoon ★ A hot-plate ★ Water ★ A match

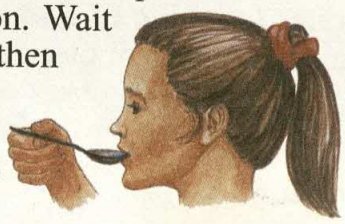
Directions

1. Ask an adult to boil water in the saucepan. Pour this into the cup and dissolve a spoonful of coffee into it.

2. Take a spoon (this must be cold and quite dry) and hold it in the steam which rises up from the cup.

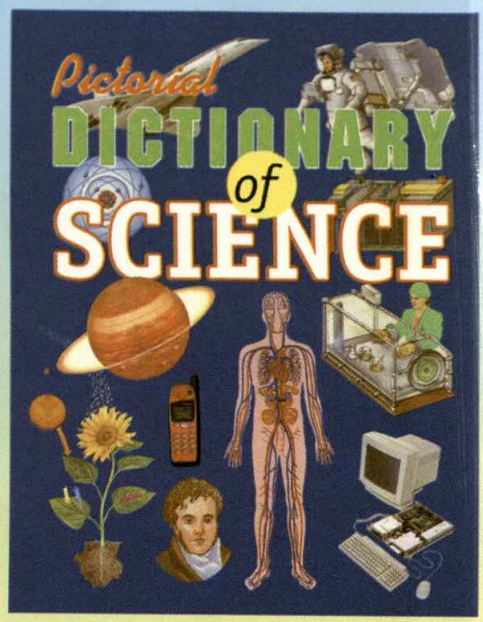
Result

After a few moments, drops of water form on the spoon. Wait until these cool, then taste them. They will be pure water, not coffee.



Reason

Because heat makes the water evaporate, but not the coffee. When the steam comes into contact with the cold surface of the spoon, it condenses into drops of pure water. You can do the same test with clear water and salt. The drops which condense will always be pure water.



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